THE

# MODEL ENGINEER and ELECTRICIAN.

EDITED BY

PERCIVAL MARSHALL, A.I.Mech.E.

**Published every Thursday. Price 2d. Post Free, 3d.**

A Splendid Paper for Young Engineers, Apprentices, Students, and Amateurs interested in Mechanics and Electricity.

## Special Features:

**Practical Articles** by experienced writers on the construction and working of model steam, gas, and oil engines; model locomotives and railways; model boilers; model steam and electric launches, and sailing yachts; model aeroplanes; motor cycles; lathes and metal and woodworking tools; pattern making; brass and iron founding; forging; model dynamos and motors; electric bells, telephones, and batteries; accumulators; electric lighting; influence machines; electrical experiments, etc., etc.

**Model Engineers and their Work.**—Illustrated Interviews with prominent model engineers, describing their workshops, their methods of working, and some of the models they have made. These are most interesting and instructive articles, and are fully illustrated from photographs.

**Our Beginners' Column.**—A section devoted to elementary instruction on the use of tools, the making of simple apparatus and models, and the carrying out of easy electrical and other scientific experiments.

**Practical Letters from our Readers.**—A correspondence column, wherein readers can describe workshop appliances or methods of their own invention, and discuss practical matters of mutual interest.

**News of the Trade.**—Under this heading short descriptions of new tools, apparatus, and materials are inserted, thus keeping the reader posted up in the latest improvements connected with his hobby.

**A System of Queries and Replies,** by which all readers of the Journal requiring information and advice on mechanical or electrical subjects can obtain replies by post within a few days. All replies of general interest are published in the following issue of the paper, so that while the individual enquirer can obtain the required assistance promptly, the remainder of the readers are not deprived of the interesting miscellany which a "Queries and Replies Column" always affords.

**Original Working Drawings** and high-class illustrations are a regular feature of the Journal.

**Prize Competitions,** open to all readers, are announced from time to time, the subjects of which are sufficiently diverse in character to suit the tastes of both mechanical and electrical workers.

**Send 3d. for Specimen Copy.**

PERCIVAL MARSHALL & CO.

26-29, Poppin's Court, Fleet Street, LONDON, E.C.

PRACTICAL INDUCTION COIL CONSTRUCTION. 1/- net. 8

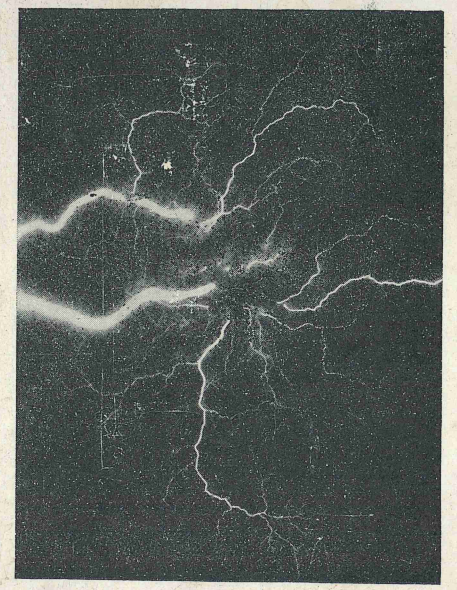
No. 8.

MARSHALL'S PRACTICAL MANUALS.

# PRACTICAL INDUCTION COIL CONSTRUCTION

PRICE 1/- NET...

FULLY..... ILLUSTRATED



PERCIVAL MARSHALL & CO., LONDON, E.C.

# THE "MODEL ENGINEER" SERIES OF HANDBOOKS.

**Price 6d. net each; post free, 7d. each.**

No. 1. **Small Accumulators:** How Made and Used. 40 Illus.
No. 2. **The Slide Valve:** Simply Explained. 36 Illustrations.
No. 3. **Electric Bells and Alarms.** 52 Illustrations.
No. 4. **Telephones and Microphones.** Fully Illustrated.
No. 5. **Electric Batteries:** How to Make and Use Them. 34 Illus.
No. 6. **Model Boiler Making.** Fully Illustrated.
No. 7. **Metal Working Tools** and Their Uses. Fully Illustrated.
No. 8. **Simple Electrical Working Models.** Illustrated.
No. 9. **Simple Mechanical Working Models.** Illustrated.
No. 10. **Small Dynamos and Motors.** Illustrated.
No. 11. **Induction Coils for Amateurs:** How to Make and Use Them. Fully Illustrated.
No. 12. **Model Steamer Building:** Hulls and Deck Fittings. Fully Illustrated.
No. 13. **Machinery for Model Steamers.** Fully Illustrated.
No. 14. **Small Electric Motors.** Illustrated.
No. 15. **Simple Scientific Experiments.** 59 Illustrations.
No. 16. **Meteorological Instruments and Weather Forecasts.** Fully Illustrated.
No. 17. **The Locomotive:** Simply Explained. Illustrated.
No. 18. **Simple Experiments in Static Electricity.** Fully Illus.
No. 19. **X-Rays:** Simply Explained. Fully Illustrated with Drawings and Photographs.
No. 20. **Patents:** Simply Explained. Illustrated.
No. 21. **Mechanical Drawing:** Simply Explained. Illustrated.
No. 22. **Electric Lighting for Amateurs.** Fully Illustrated.
No. 23. **Model Steam Turbines:** How to Design and Build Them. Fully Illustrated.
No. 24. **Small Electrical Measuring Instruments:** How to Make and Use Them. Fully Illustrated.
No. 25. **The Beginner's Guide to the Lathe.** 75 Illustrations.
No. 26. **Gas and Oil Engines Simply Explained.** Illus.
No. 27. **A Guide to Standard Screw Threads and Twist Drills.** Small Sizes.
No. 28. **Model Steam Engines.** Illustrated
No. 29. **Simple Photographic Experiments.** Illustrated.
No. 30. **Simple Chemical Experiments.** Illustrated.
No. 31. **Electrical Apparatus:** Simply Explained. Illustrated.
No. 32. **The Wimshurst Machine:** How to Make and Use It. Illustrated.
No. 33. **Alternating Currents** Simply Explained. Illustrated.
No. 34. **Magnets and Magnetism:** Simply Explained. Fully Illus.
No. 35. **Optical Instruments:** Simply Explained. Illustrated.
No. 36. **Windmills and Wind Motors.** Fully Illustrated.

*Other Useful Books for this Series are in course of Preparation.*

MAY BE ORDERED THROUGH ANY BOOKSELLER.

**PERCIVAL MARSHALL & Co.,**
**26-29, Poppin's Court, Fleet Street, London, E.C.**

THE

# Engineer's Pocket Dictionary.

## FRENCH—ENGLISH.

By M. LVOFF.

A Comprehensive Dictionary of the various Technical Terms used in Engineering, Electrical and Cycle and Motor Books, Papers, and Catalogues.

Some **3,000 French Technical Words and Phrases,** with their correct English equivalents, are given.

It has been compiled for Engineers by an Engineer, and is really accurate. It is very compact in size, and has a Thumb Index, so that any word can be found at once.

Price **1/6** net; post free, 1/7. From all Agents for THE MODEL ENGINEER, or from—

**PERCIVAL MARSHALL & Co.,**
**26-29, Poppin's Court, Fleet Street, London, E.C.**

## IF YOU WISH TO BUY, SELL, OR EXCHANGE

Model Engines, Parts, Castings, Fittings, Lathes, Tools, Model Yachts, Dynamos, Motors, Electric Bells, Batteries, Telephones, Induction Coils, *X*-Ray Appliances, Switches, Pushes, Indicators, Experimental and Scientific Apparatus, Technical Books, anything Mechanical or Electrical, or Motor Cycles, &c.

**THE BEST MEDIUM FOR YOUR ADVERTISEMENT IS**

# "The Model Engineer and Electrician."

**Published every Thursday, Price 2d.**

**Circulates in all Parts of the UNITED KINGDOM and the COLONIES.**

Rates for **Advertisements** in the "Sale and Exchange" Column—**6d.** for first **18 words** or less; **Halfpenny** per **word** after. All communications should be addressed to—

The Advertisement Manager, "THE MODEL ENGINEER,"
**26-29, POPPIN'S COURT, FLEET STREET, LONDON, E.C.**

## MARSHALL'S PRACTICAL MANUALS.

**Price 1s. Post Free 1s. 3d.**

**No. 1.—The Beginners' Guide to Carpentry.** *A Practical Handbook for Amateurs and Apprentices.* By HENRY JARVIS. 128 pages. 99 illustrations.

**No. 2.—Private House Electric Lighting.** *A Popular Work on Modern Methods of Wiring and Fitting as applied to Private Houses.* By FREDERIC H. TAYLOR, A.M.I.E.E. 128 pages. 68 illustrations.

**No. 3.—Petrol Motors Simply Explained.** *A Practical Handbook on the Construction and Working of Petrol Motors.* By T. H. HAWLEY. Revised by ERIC W. WALFORD. 97 pages and Index. Fully illustrated.

**No. 4.—Model Sailing Yachts:** How to Build, Rig, and Sail Them. *A Practical Handbook for Model Yachtsmen.* 144 pages. 107 illustrations.

**No. 5.—Practical Dynamo and Motor Construction.** *A Handbook of Constructive Details and Workshop Methods used in Building Small Machines.* 125 pages. 133 illustrations.

**No. 6.—Practical Motor Car Repairing.** *A Handbook for Motor Car Owners and Drivers.* By ERIC W. WALFORD. 140 pages and an index. Fully illustrated.

**No. 7.—Practical Bookbinding.** *A Text Book intended for those who take up the Art of Bookbinding.* By W. B. PEARCE. 132 pages. 92 illustrations.

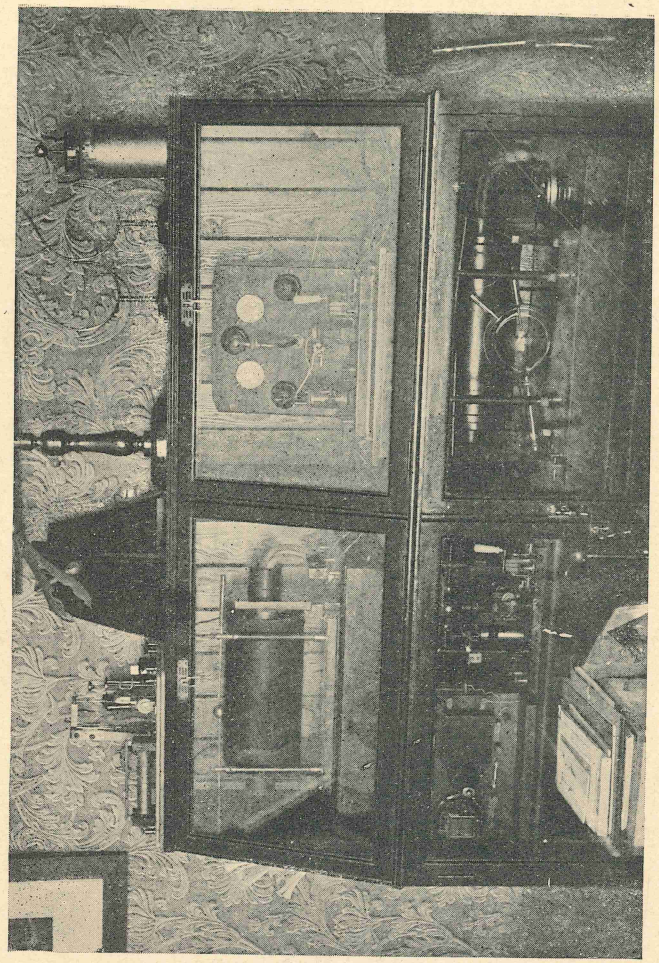
**No. 8.—Practical Induction Coil Construction.** *A Handbook of Constructive Details and Workshop Methods used in Building and Repairing Modern Spark Coils.* By JOHN PIKE. 128 pages. 36 illustrations.

**No. 9.—Practical Electro-Plating.** *A Practical Handbook on the Apparatus and Processes employed in the Electro-Deposition of Metals.* By GEORGE GENTRY. 106 pages. 41 illustrations.

**No. 10.—Workshop Wrinkles and Recipes.** *A Collection of useful Workshop Hints in Mechanics and Electricity.* Edited by PERCIVAL MARSHALL. 96 pages. Illustrated.

**Other Books to follow in this Series.**


# PRACTICAL
# INDUCTION COIL CONSTRUCTION.



The Author's Cabinet for X-ray Apparatus, Spare Coil, Breaks, Batteries, and other Accessories.

**Marshall's Practical Manuals. No. 8.**

# PRACTICAL INDUCTION COIL CONSTRUCTION.

*A Handbook of Constructive Details and Workshop Methods used in Building and Repairing Modern Spark Coils.*

BY

JOHN PIKE.

*ILLUSTRATED WITH ORIGINAL PHOTOGRAPHS AND DRAWINGS.*

LONDON:

PERCIVAL MARSHALL & CO.,

26-29, POPPIN'S COURT, FLEET STREET, E.C.

# CONTENTS.


| CHAPTER. | | PAGE. |
|---|---|---|
| I. | BATTERIES .. .. .. .. .. | 7 |
| II. | SPECIFICATION FOR SPARK COILS .. .. | 14 |
| III. | THE CORE .. .. .. .. .. | 24 |
| IV. | WINDING THE PRIMARY AND FINISHING THE CORE .. .. .. .. .. | 28 |
| V. | THE CONDENSER .. .. .. .. | 34 |
| VI. | THE COMMUTATOR .. .. .. .. | 39 |
| VII. | DISCHARGING PILLARS AND RODS .. .. | 42 |
| VIII. | BREAKS .. .. .. .. .. | 45 |
| IX. | THE SECONDARY WINDING .. .. .. | 61 |
| X. | WAXED PAPER SEPARATING DISCS .. .. | 69 |
| XI. | THE OPERATION OF WINDING DOUBLE SECTIONS .. .. .. .. .. | 72 |
| XII. | BUILDING-UP THE DOUBLE SECTIONS .. | 83 |
| XIII | FINISHING OFF THE COIL .. .. .. | 90 |
| XIV. | SOME SPECIFICATIONS OF COILS .. .. | 101 |
| XV. | RADIOGRAPHIC WORK .. .. .. | 107 |
| XVI. | THE REPAIR OF SECTIONALLY WOUND SPARK COILS .. .. .. .. .. | 118 |
| XVII. | ELECTROGRAPHIC WORK .. .. .. | 126 |


# PREFACE.

THE subject matter of this book appeared first in the pages of THE MODEL ENGINEER AND ELECTRICIAN. The chapters have been carefully revised for the purpose of publication in their present form, and are submitted as a record of practical work in the building of "spark coils," without the burden of ancient matter, and with something novel in the way of efficient and easily made "breaks."

In the chapter treating of the "secondary" winding the method of insulation with waxed cotton has been retained, in deference to some opinions publicly expressed. It may be stated here, however, that the method may, in the writer's view and experience, be safely discarded. Waxed cotton gives a very neat finish, and some strength to a thin section of wire, but as a di-electric is not so good as pure wax: it will not prove a safeguard against "leakage" if the elements of this be present, and certainly prevents a quick and accurate diagnosis in the event of a breakdown. If not used, the specifications must be altered to the extent of providing separating discs of slightly larger diameter, so that the equivalent of pure wax insulation may be allowed for.

J. P.

Sherwood,
Nottingham,
*March*, 1908.

LONDON:
PRINTED BY HAMPTON AND CO.,
12-13, CURSITOR ST., E.C.

# Practical Induction Coil Construction.

## CHAPTER I.

### BATTERIES.

THE source from which the operator is to derive the supply of electrical current necessary for working his coils is conveniently considered in the commencement of this book. It must be said that many existing handbooks dealing with the subject of spark coils give somewhat unqualified statistics when the important detail of battery power is treated—*e.g.*, we read in two such works specifications of coils of various sizes which run—other details being omitted—in this fashion :—

| Spark length of coil. | E.M.F. required. |
|---|---|
| 1 in. .. .. .. | 8 to 12 volts. |
| 2 ins. .. .. .. | 12 ,, |
| 3 ins. .. .. .. | 12 ,, |
| 4 ins. .. .. .. | 12 ,, |
| 6 ins. .. .. .. | 16 to 20 ,, |

All of which are misleading and likely to seriously handicap the operator. The amateur might very

well be deterred from building a 6-in. coil by reason of the assertion that so much battery power would be required to bring out its specified capacity. All the coils figured in this book are supplied from at most six cells (12 volts), and give the full length of spark, using one or other of the mercury breaks illustrated. As a rule, however—and one or another is in daily use—no more than four cells (8 volts) are used.

Of primary batteries, the kind usually chosen will be the bichromate (bottle) cell. This has, when freshly charged, an E.M.F. (electro-motive-force) of 2 volts, which quickly falls to 1·50; therefore, for the 6-in. coil referred to in the above table, thirteen or fourteen such cells would be required to give what we may term a "steady" 20 volts.

Such cells as the bichromate, unless constantly cleaned out and recharged (the best charge is—

| | | |
|---|---|---|
| Chromic acid | .. .. | 6 ozs. |
| Water | .. .. .. | 36 ozs. |
| Sulphuric acid | .. .. | 3 ozs. |

mix the latter acid gradually with the water, then add the chromic acid), are of small practical value in radiographic work, for the main reason that as usually sold or purchased they are much too small. The current fails, and the novice adds cell to cell, with the result that his "break," if of the usual hammer type, sticks—the platinum contacts fusing by reason of the great heat generated—and, sooner



or later, his coil breaks down. Every additional cell means greater risk of this catastrophe.

The expression has been used "cells of fair size and capacity." This, so far, conveys no information of real value. In this book any reference to "cells" will, unless otherwise stated, mean storage cells—secondary batteries—or accumulators: the capacity being not less than 21 amps. A useful class of accumulator for the purpose is the battery fitted up in a celluloid case and sold for motor-car spark ignition. They are sold in pairs as 4-volt accumulators, each cell having a steady 2-volt pressure, and when chosen of the larger sizes they answer very well for "coil" work, being reliable, portable, and well-made, and may, now-a-days, be readily recharged.

The capacity of ampere-hours depending upon the surface area of the positive plates in each cell, it follows that increased capacity must mean increased weight and larger bulk. The makers of the "E.P.S." storage batteries adopt a plan in describing them which gives the information required by the intelligent purchaser—this is, the number and size of plates in each cell. Thus, a 4-volt (two-cell) battery of 21 amp.-hours capacity contains in each cell seven plates (four negative, three positive), each measuring 4 ins. by 4 ins.; the 35 amp.-hours battery contains in each cell eleven such plates; and the 70 amp.-hour twenty-one in each cell. The weight of the latter battery (4-volt two-cell) comes out at about 56 lbs.: a weight

which is, to say the least, inconvenient; but it is clear evidence of the fact that if we want capacity we must put up with increased weight.

The term "ampere-hour" indicates that a battery of, say, 21 amp.-hour capacity will give current at the rate of 1 amp. for twenty-one hours, or 3 amps. for seven hours; thus, if we have a small lamp which takes $\frac{1}{2}$ amp., this ought to be lit continuously for forty-two hours.

As induction coils designed to give sparks from 3 ins. to 10 ins. have their primary winding mostly of a gauge not less than No. 14 S.W.G., and as this wire carries a current of 9 or 10 amps., it is easy to understand that if the current is available it is very easily taken. It follows that the current consumed in working spark coils is much greater than is generally said to be the case. An ammeter or amperemeter and a voltmeter should always form part of an outfit. Adjusting the ammeter in series with the battery and coil, the operator can tell at once how much current he is consuming, and with the voltmeter he finds out, by connecting it by wires to the terminals of his battery, the condition (as to voltage) of the battery as a whole, or each cell separately. In a subsequent chapter will be found described a switchboard fitted with ammeter and voltmeter for this purpose, together with diagrams of connections.

Depending to some extent, of course, on the class of break used, the ammeter will usually register something like 6 to 9 amps. It follows that the



batteries should be of large size so as to be able to give the current required without damage to the plates. Accumulators, as a rule, are labelled with a notice to the effect that a safe discharging rate is a certain number of amperes. This rate is undoubtedly being often exceeded without the user being aware of the fact, and very often also—as the writer experiences—without any damage; but this refers to short runs only.

Summing up the matter of batteries—accumulators are strongly recommended. They should be chosen of the largest capacity possible, the considerations being weight and price. If the reader can see his way to two 3-cell batteries, with twenty-one plates in each cell, and is prepared to negotiate the weight of them (approximately, with acid, 224 lbs.) he will be sure of all the current he requires. Failing these, of course, his choice must fall on those containing fewer plates as being more portable and less costly, but it should be noted that each cell contains not fewer than seven plates, each 4 ins. by 4 ins.

What has been said on the matter of bichromate batteries refers mainly to the "bottle" bichromate in which the zinc plate is small, even in the quart or three-pint sizes. If, however, cells much larger than these are purchased, in which the carbons and zincs more nearly approximate 9 × 6 ins.—moreover, if they are built with two zincs and three carbon elements, then the bichromate battery will, no doubt, be found useful; at least, three cells

would be required. For the motor break, two "pint bichromate batteries" will be found convenient, as the motor runs easily with 3 volts.

Of sealed batteries, the only really practical cell is the Edison-Lalande, the E.M.F. is under 1 volt, and the amperes about 300. Several of these would be useful, the largest size especially so. Twelve of these would equal a four-cell accumulator and there would be plenty of available current.

The accumulators are charged from a direct current supply very easily. In most towns this is available, and if the user has access to any installation, nothing is simpler than to charge from the nearest or most convenient circuit, using a 50 c.-p. lamp as resistance; the sketch herewith (Fig. 1) shows how this is done. The time taken to charge a 4-volt battery—*i.e.*, two-cell (seven 4 × 4-in. plates in each) would be about twelve or fourteen hours.

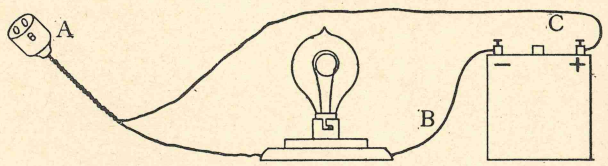



FIG. 1.—DIAGRAM OF CONNECTIONS FOR CHARGING ACCUMULATORS.

A length of silk-covered twin lamp wire is connected firstly to an adapter, A, and at some convenient place the two strands are separated as shown. One of them is then cut, and the bared end made fast



to the socket, the piece cut off also connected and carried out for attachment to the battery. The two terminating wires must not be attached to the battery terminals until we have ascertained their polarity. Now, a lamp being removed from the nearest or most convenient bracket, the plug or adapter is put in its place—a 50 c.-p. lamp is also to be put in the socket. Having at hand a small glass of water, slightly acidulated, the bared wire ends of B and C are dipped in it, keeping them about ½ in. apart. The current being switched on, bubbles of gas will be evolved from the wire which is negative, and this wire must be attached to the negative terminal of the accumulator marked — and commonly painted black; the other wire is positive (+) and is attached to the + terminal, painted red.

If the adapter can be left permanently in place, the + wire may be coloured red—a drop of red sealing-wax—and we then know on future occasions how to connect the wires; but if after charging the apparatus is removed and put away, then it will be safest to always test the wires for polarity before fixing to the accumulator terminals for another charging.

In place of the acidulated water, a piece of "pole-finding paper" may be used. It is also a convenience to have a china turn or tumbler switch—of suitable size for the voltage and current used—fixed to the board.

## CHAPTER II.

### Specification for Spark Coils.

The writer finds a difficulty in writing on this matter, owing to the fact that from a given specification no two persons will get the same result. The various coils to be illustrated in this book, with full accompanying details, are samples of what any earnest, careful, and intelligent worker may obtain by following the directions for working fully set out. For greater convenience of writing the 9-in. coil will be most fully treated (Fig. 2). If a standard be taken of 1-in. spark from each pound of wire in the secondary winding, the careful reader should—by using these specifications—meet with no difficulty in slightly exceeding this result.

Presuming the reader is conversant with general electrical principles, we may recapitulate that the induction or "spark" coil consists of a "core"—a bundle of soft-iron wires, gauge 22, tightly bound into a cylinder, covered with a winding of silk ribbon and wound with two or three layers of stout copper wire (No. 14 S.W.G.), and termed "the primary": this is now enclosed in a stout ebonite tube, and upon this tube is built up the "secondary," consisting of



many thousand turns of fine wire, usually No. 36 S.W.G. A contact-breaker is in series with one of the wires leading from the battery to the primary, the object of which is to suddenly cut the supply at a rate of 20 to 2,000 per minute. Every time the contact is broken a spark appears between the terminals of the secondary, these being adjusted near to each

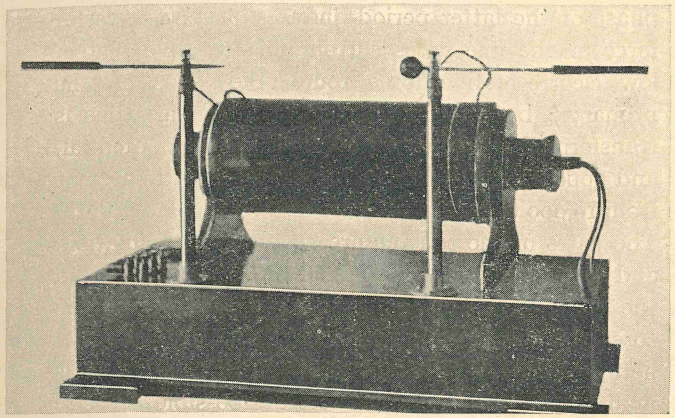


Fig. 2.—A 9-in. Spark Coil.

other, caused by the inductive action of the current in the primary, enhanced by the magnetic condition of core.

The core is built up of iron wires, soft and carefully annealed—soft and annealed to ensure full magnetisation when the current is passed, and complete de-magnetisation when it is withdrawn. The magnetised core displays lines of force in

well-known forms. The current is sent round the core through the primary winding, and large wire is used, because, firstly, it carries a heavier current, and, secondly, because with the large wire there is less self-induction—the neutralising action of close turns of wire one with the other when a current is passed through them. The core, fully magnetised and suddenly de-magnetised, at every phase of the latter period induces a very powerful force in the fine wires surrounding it. We send a low electro-motive force round the turns of the primary; but in the coils of the secondary this is transformed into energy of extremely high potential, and appears at the terminals as a spark estimated at from 10,000 to 15,000 volts for every inch of its length. The parts of the coil require very careful insulation, and the object of coil makers is, briefly, to wind the secondary wire as closely as possible to the core—that is to say, well within the lines of magnetic energy—and at the same time to get on as many turns of the fine wire as it is possible by close winding to obtain; but the insulation must be thoroughly sound throughout.

A condenser is very necessary, and plays a most important part in the construction of spark coils. Connected up to the contact break—*i.e.*, the platinum pin and pillar on the one side, and the platinum contact and spring on the other—it absorbs the extra current in the primary circuit at "break" and parts with it at "make." The very detrimental self-induction in the primary circuit is largely



minimised by its use. The primary current passes through at full strength, the core being magnetised and de-magnetised at once and without loss of time and energy; the sparking also at the contacts is reduced to the smallest dimensions.

It will be seen on examining the extended plan of the 9-in coil (Fig. 4) that at the ends of the secondary bobbin there is less wire, there being greater insulation at each end. In small spark coils of 1 in and under, these condary may be wound in layers, each layer separated from the next by waxed paper extending from one end of the coil to the other; but in larger coils this is not admissible. The great tendency of the charged wire is to spark laterally from one turn to the other.

The fine results achieved in the coils, which will be figured later on, are due, no doubt, to the parts being thoroughly well balanced. It is probably the fact that all the secondary winding is well within the lines of strongest electrical energy. The reader will do well to draw these out to scale, and study carefully the relation of core (diameter and length) to secondary, the shape and diameter of the latter, the careful winding to get on the largest number of turns in the space provided, and the thickness of the insulation between the primary and secondary.

The word "space" used above must be understood to refer to length of secondary bobbin, not to its thickness It is far better to lengthen the core (and primary) than to increase the depth of

the secondary windings. The method of winding the secondary wire is that of double "sections," as described by the writer in THE MODEL ENGINEER AND ELECTRICIAN for November 26th, 1903; April 28th, 1904; May 5th, 1904, etc.

It was discovered very early in the manufacture of spark coils that the necessary insulation could only be obtained by winding in vertical sections—firstly by subdivision of the space to be filled into two, four, six, eight, or more sections each, separated by a stout ebonite disc; and, finally, by further subdivision, the thickness of the section of wire now being in large coils frequently 1-16th in. To wind a number of thin sections of wire is the easiest task, but the connecting them up afterwards and on the ebonite tube upon which they are to be built proves a very tedious business. The author, indeed, never built a coil in any other than the method treated here, as, carefully thought out beforehand, it seemed impossible to imagine a better way of securing efficient insulation close to the tube. The fine wire must frequently be severed and re-joined. So long as the joints are small, well soldered and insulated, the number of them is practically of no importance; and it was consequently felt that the joint connecting one section to its fellow (forming a pair) was best made while the sections were being wound, so that no loose wire and joint has to be tucked into the small annular space between the tube and the sections. As one writer puts it, "having made as thin and small a



joint as possible, when soldered it must be carefully pushed just between the insulating paraffin paper discs and covered with paraffin." The directions are the more difficult to carry out because the paraffined paper discs in the specification referred to have a central aperture of $2\frac{7}{8}$ ins., and are to "slide over" a tube 3 ins. in diameter.

### SPECIFICATION OF THE SPARK COIL (FIG. 2).

*Core*—13 ins. by $1\frac{1}{8}$ ins., perfectly straight iron wires, No. 22 gauge, re-annealed and put together as to be described.

*Primary*—two layers, No. 14 D.S.C. wire, about 3 lbs.; 290 turns.

*Ebonite tube*—17 ins. long, $2\frac{1}{4}$ ins. outside diameter, $\frac{1}{4}$ in. thick; inside diameter therefore $1\frac{3}{4}$ ins.

*Ebonite discs*, to form the cheeks of secondary bobbin, $\frac{1}{2}$ in. thick, 6 ins. diameter, central aperture, $2\frac{1}{4}$ ins.

*Secondary wire*—$8\frac{1}{2}$ lbs. of No. 36 S.W.G., S.C.C., wound in fifty double sections; two thicknesses of waxed blotting-paper between each disc of wire.

*Length of secondary* between the two ebonite cheeks, 12 ins. (if single *silk* had been used this space would have been reduced to about 10 ins.).

*Number of turns* of wire on the secondary, 30,000 approximately.

*Condenser*, to be described.

*Total cost* of above, including winding apparatus (but not the former discs), under £5.

It is conceivable that the core is, in many specifications, much too long and thick. It is hardly possible to thoroughly magnetise even a thin core; the wire used on the primary winding will carry 9 amps. or so, and we can get, if extremely careful, twelve turns to the inch. Now, remembering that on the assumption that it takes 1,000 amps. to thoroughly magnetise a square inch section of iron, which amount of current we may send round the iron in one turn, or in one hundred turns of 10 amps. each—hence the term "ampere turns"—it is clear that the space at command is limited. Mr. Hare has observed that three layers of primary are little, if any, better than two—that, in fact, no advantage accrues from the third layer, except for coils built for high voltage and those to be used in conjunction with Wehnelt breaks. We are driven to the conclusion that in deciding upon the diameter and length of the core some considerations of symmetry were to the fore; or possibly the idea was that the structural stability of the coil would be better preserved if the core were chosen of respectable dimensions. The accompanying diagram (Fig. 3) shows fairly well the proportions of secondary winding to suit a core of given size—*e.g.*, if 1 in. be the diameter of the core, the secondary winding should not be nearer (for saftey) than ½ in., nor be further off than 1¾ ins.; that is to say, the outside turns need not be carried outside this line. It is true,



of course, that the more wire you can get on the longer the spark; but this only refers to a circumscribed space, beyond which it is futile to go. Careful winding, therefore, is indicated so that the turns of wire lie close together—not loosely—so that no space

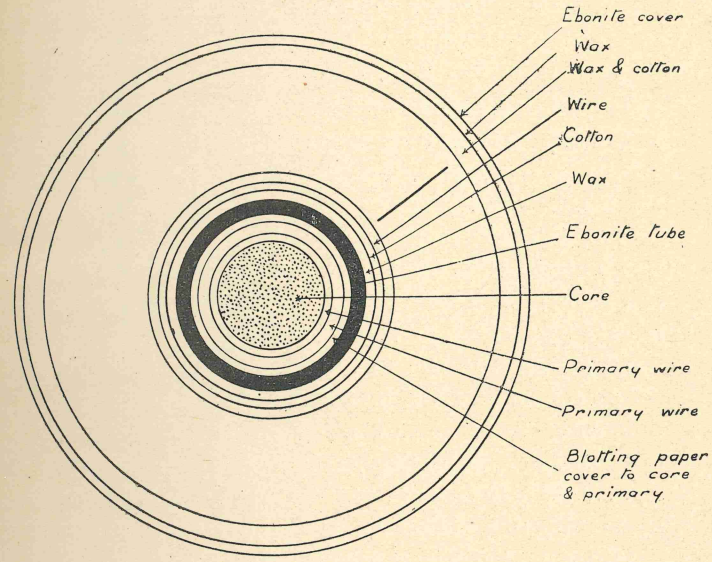



FIG. 3.—DIAGRAM SHOWING PROPORTIONS OF SECONDARY WINDING, ETC.

is lost. The secondary bobbin may be very nearly the full length of the primary winding.

Returning for a moment to the core, it may be remarked here that to the coil (Fig. 2) the writer has three cores, either of which will slide within the

ebonite tube on which the secondary wire is built.

First core—12 ins. long, $1\frac{1}{4}$ ins. diameter, 260 turns of No. 14 S.W.G. wire.

Second core—13 ins. long, $1\frac{1}{8}$ ins. diameter, 290 turns of No. 14 S.W.G. wire.

Third core—15 ins. long, $1\frac{1}{8}$ ins. diameter, 350 turns of No. 14 S.W.G. wire.

Testing these cores with the mercury break a $10\frac{1}{2}$-in. spark was obtained with No. 1, using 12 volts 6 amps.; Nos. 2 and 3 are not so effective as this, but No. 2 is generally used, and with this (or No. 3 for that matter) a 9-in. spark is always to be had with 10 volts 6 amps. As a rule, however, the coil is used with four cells (8 volts) only, and gives readily $8\frac{1}{2}$ ins. of spark.

With regard to the wire used, only the best and softest copper wire is admissible. There is considerable difference, some makes being much softer than others. For the primary, double silk-covered (No. 14 S.W.G.) may be used, as there is little to be gained by substituting cotton-covered, and no gain at all so far as efficiency is concerned. With double cotton-covered wire more room would be taken up in the horizontal and vertical lines, whereas the silk-covered wire will wind closer, not only in the turns but the layers. With the secondary, however, considering the quantity required, the saving is great if single cotton is used in place of single silk (No. 36 S.W.G.). It is frequently remarked that cotton-covered is



"just as good." That is correct, but there are reservations to be made. Single cotton-covered is cheaper, and is easier to wind. The cotton (well dried) takes a good coating of wax; hence in the sections there is little risk of leakage. The only remark to be made against it is that it takes up more room. The difference in the writer's experience

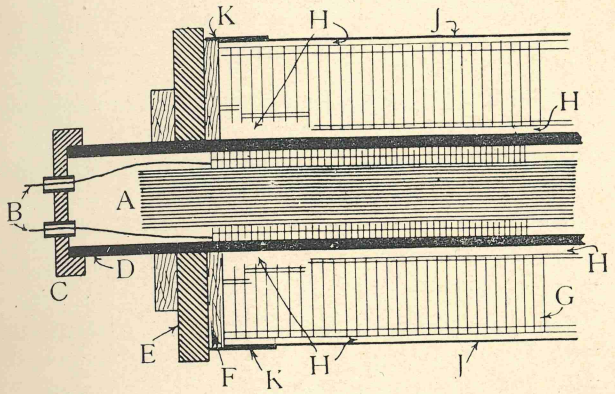



FIG. 4.—SECTION OF ONE END OF COIL. (*About* $\frac{1}{4}$ *full size*). A, Core; B, Primary; C, Ebonite Cap; D, Ebonite Tube; E, Ebonite Disc; F, Wood Disc; G, Wire Sections; H, Wax; J, Ebonite Cover; K, Ditto (extra at ends).

may be expressed thus: If a certain quantity of single silk-covered wire takes up 5 ins. of space, then the same quantity of single cotton will take up 6 ins. It will be seen, therefore, that if cotton-covered is used a fifth more space must be provided; in other words, the specification must be modified to suit, unless, of course, cotton-covered is indicated therein.

## CHAPTER III.

### The Core.

Bundles of soft iron wire of the gauge deemed most suitable for coil construction are to be purchased at a reasonable price ready cut to length, and, if desired, straightened and made up to the diameter required. Sometimes the bundles of wire will come cut approximately only to length and very far from straight. There is an easy method of making the wires perfectly straight—a method which the author has not seen described in previous works dealing with the matter: this is to clamp one end of the wire in a strong vice, which must be firmly fixed to the bench, now with a pair of strong pliers take a firm grip of the other end of the wire, and pull. The pull should be firm and steady and the wire will be *felt* to stretch slightly, but when released will be quite straight. To get accurate length, screw a block of wood near one end of the bench or table, the exact distance from the edge that the wire is wanted, and, using a pair of cutting pincers, or nippers—not pliers—trim one end, lay it on the bench, one end close to the block, the end projecting over the edge is cut off, leaving the wire



(if of full length to begin with) the exact number of inches required. Having straightened and cut a quantity of wire, sufficient as may be judged for the diameter desired, the bundle may be got into a true cylindrical shape by working as follows:—Bend a few spare wires into the shape of the letter "U," and place within them as neatly as possible the cut wires; being straight they will lie fairly straight and close together. Having got rather more than sufficient—it is rather difficult to guess the right number—commence to turn the ends of each "U" wire so as to firmly clamp the bundle, also place more wires round, say one for every inch or less of the length; when all are firmly secured take the bundle in the hands, and grasping it tightly, give a rotary motion to the wires; it will be found that they will fall better into line, and that we are able to tighten the binding wires. This must be done two or three times, first the rotary motion, then the tightening until—and the result is certain—we shall get a perfectly round and straight bundle and very tight. Naturally, before this we shall have seen whether more wire was necessary to get the diameter required in the finished core or whether we have too much.

It is easy when the bundle is comparatively loose to draw a few wires out or put a few more in, and measurements should be taken several times during the operation. The result is a truly symmetrical core, as there will be practically no overlapping of the wires.

Although the wire has been bought as " annealed " or " re-annealed," it is desirable to do this one's self; therefore, before interfering in any way with the binding wires beyond cutting them pretty close, place the bundle within a piece of iron tube, and after plugging the ends with wood put the whole in a good fire, make red hot, and allow to cool slowly in the ashes; the wood ends only serve, for the time, in keeping cinders and dirt out; the iron tube being lifted carefully from the ashes, the annealed core is removed comparatively clean.

It may not be absolutely necessary to re-anneal a core which—as wire—has been already annealed; but after the operations of straightening and making up it may be that it is a wise precaution. There is no question that the secret of the little extra spark length we get in any finished coil is that every part has been very thoroughly done.

The method just described is rather rough on the hands, but as thick gardening gloves are easily procurable, and cheap, the risk of damage to the cuticle may be much minimised.

The core is finished by (after cleaning with a dry hard brush) carefully taping with silk. Provide a sufficiency of silk ribbon and dry it. Then wind tightly round the core, removing the binding wires as they are severally reached, and finishing off by sewing or securing with stitches the first and last turns. If $\frac{1}{2}$ in. tape is used it may be allowed to overlap half its width so that we get a



*neat and even* double layer of silk the whole length of the core.

The next operation is to soak the core with its silk covering in shellac varnish or hot paraffin wax until every part is thoroughly permeated. If shellac varnish be used (shellac, 2 ozs.; methylated spirits, 1 pt.), the core must be drained well, and then dried in an oven. Perhaps, in view of a further reference to the matter in the next chapter, it may be thought best to simply soak the core in hot wax, when, after draining, it will be ready for the primary winding.

## CHAPTER IV.

### Winding the Primary and Finishing the Core.

The gauge of wire used for the primary is No. 14 B. or S.W.G. The wire has a diameter of ·08 in., and if selected with silk covering we are able to get on the core at least ten turns to the inch linear with close winding. It is important to have the turns of wire tight and close; No. 14 wire carries 9 amps., and the more wire you get on the greater the number of ampere turns and the better magnetisation of the core. It cannot be too often urged upon the student how important it is to do every portion thoroughly; laxity here and there—even if the insulation is good—is sure to be demonstrated by moderate performance of the finished coil. If the best and *softest* wire is obtained there are no difficulties to be met with in winding on No. 14 or even No. 12 wire; two persons are better than one for this work—one for the purpose of paying out the wire and keeping also a fair strain upon it, while the other has his attention solely fixed upon the winding.

Commencing the work, bend a foot or so of the wire neatly to a right angle with its axis, and secure the turn as tightly as possible with silk twist or



ribbon to the iron core—already taped and waxed—at a distance of $\frac{1}{2}$ in. from the end; then, keeping meanwhile a fair strain on the wire, slowly and steadily revolve the core; the soft wire bends easily round the cylindrical core, and passing over straight, drops readily into even and close turns, aided thereto by the fingers of the operator. If there is a tendency on the part of the wire to slip, then the silk tape and first few turns may be not only tied, but stitched and waxed with a little paraffin wax, allowing it to set quite hard before starting again. Arrived to within $\frac{1}{2}$ in. from the opposite end we take the next turn over the first layer, and so continue winding on the second layer in the grooves made by the first, until, having reached the end from which we started, the last turn is tied tightly with tape or silk twist, leaving a foot or so of the wire turned out to a right angle as was the first and at the opposite side to it; this also may be stitched down and freely waxed.

The core (and primary) now present a neat appearance, being symmetrical if the work has been carefully done—straight and circular—but it will be a loose fit in the ebonite tube. It is desirable on many grounds to have the *core* with its *primary winding* removable. In most large coils it is usual to enclose the core, etc., within a stout ebonite tube, which then passes within a second tube on which has been built the "secondary." This for an amateur is likely to prove beyond his powers. Ebonite tube is very uncertain with regard to its internal and outside diameters—outside, in particular. It would

be necessary to place the first tube in the lathe and turn down, to ensure anything approximate to an accurate fit.

The *desideratum* of a movable core and primary is, however, achieved in the coil we are specifically treating, by enclosing it in a fold or two of the same waxed blotting-paper used for the secondary divisions; for this purpose four half-sheets of the blotting-paper are carefully dried and thoroughly waxed. The bundle of iron wires is of $1\frac{1}{8}$ in. diameter; when taped it is a little more than this and the two layers of primary bring it to about $1\frac{5}{8}$ ins. or less. The ebonite tube into which it is to be placed is $1\frac{3}{4}$ ins. Now, having wound the primary and secured the two projecting ends, bring these two ends straight out for at least $\frac{1}{2}$ in. beyond the core, but well away from the wire, then turn the ends up at right angles. We have now to put round the primary a piece of thin sheet zinc or tin: cut this of a length sufficient to quite enclose both ends—say 14 ins.; bend the sheet as neatly as possible, as it is necessary to have the result as truly circular as we can make it. We now require a long narrow trough of stout tin of a size to just take the core with its metal covering, which, by-the-by, must be secured tightly with wire or twine. The trough being prepared by melting therein a sufficiency of paraffin wax, the core, previously made hot by a short term in an oven, is lowered into the receptacle and allowed to remain quite covered and soaking in the bath, kept hot, for several hours, until—



in fact—no more bubbles of air are seen to issue from the ends of the tin cylinder. The whole is allowed to cool and set hard. This done, the trough is again warmed, and the contents released: scraping and cutting off the superfluous wax, we arrive at the tin cover, the wire is cut, the cover springs open with a little assistance, leaving the core and primary evenly covered, and all its interstices filled with wax. Having trimmed up the ends neatly, the ends of the primary may be straightened. We shall find as a result of this treatment that with a couple of turns of the waxed paper, which will now fold smoothly, but must be slightly warmed, the core will make a neat fit within the ebonite tube provided. As the coil has no hammer break of the usual pattern, *each* end of the core—the blotting-paper extending a little beyond its length—may be filled in with wax. A loose core of this description may be seen in Fig. 33.

Short of a separate ebonite tube nothing could be neater and more effective than the movable core built up in this manner, while the insulation is very good.

Any air space between the outside of primary and the ebonite tubes, such as naturally results if the core, etc., etc., is a loose fit, is soon made manifest by—when the coil is worked—sparking, very distinct and crackling. On looking into one end of the tube under these conditions a very interesting display of electric sparks is seen all round the outside turns of wire—the appearance is that of a ring of short bright sparks. The discharge is

evidently static and is not likely to do any damage to the coil—the noise, however, to a sensitive ear is disconcerting. It would have been an easy matter to have photographed the display, but having neglected to do so before treating the core with the blotting-paper casing, the author has now nothing to operate upon.

In the event of its being desired to use a hammer break, an " App's " or a " Vril," the core may be left short—*i.e.*, the blotting-paper may be cut so that when the wax is trimmed up at the ends the

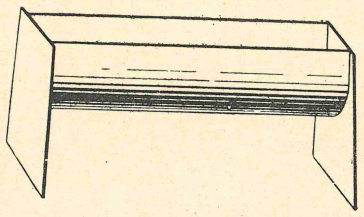


FIG. 5.—TROUGH FOR USE IN FINISHING CORES.

core measures only 14 ins., say, including wax; or, by boring or channelling out the wax at one end only—where the two primary wires project—so that the iron wires are exposed, a break of the type mentioned may be fitted. It would be necessary, however, to extend the soft-iron hammer head so that it will pass into the tunnel and go close up to the core.

A trough for the purpose above referred to is easily made by bending a piece of stout tin, 15 or 16 ins. by 12 ins., into the " U " shape and soldering



it securely to two end pieces of the same metal, after the pattern of the figure annexed. The height will be determined, of course, by the source of heat to be placed beneath. The writer uses a gas stove, supplemented by a spirit lamp. The model may be strengthened in any way deemed desirable, but one made—in a few minutes—precisely as described has served for several cores, and is still in good condition. (Fig. 5.)

## CHAPTER V.

### The Condenser.

The condenser provided for the coil, and fixed in the box upon which it stands, is of the Fizeau type, and consists of seventy sheets of tinfoil interleaved with waxed paper of good texture and quality. A suitable paper is a good quality white demy such as is used largely by chemists—but it should not be the *best* from the trade point of view. A tough fairly thick paper is to be had which has very little sizing in it. Enough should be provided to make one hundred and sixty or so sheets 13 ins. by 8 ins. The tinfoil sheets, full size, measure 14 ins. by 11 ins. and each sheet therefore makes two 11 ins. by 7 ins., which is a size very suitable for the dimensions required. Each sheet of foil used in the condenser has on either side two sheets of the waxed demy paper. The demy should be well dried and thoroughly waxed in the paraffin wax bath as suggested for the blotting-paper discs.

In addition to the large sheets of foil, seventy small pieces (2 ins. by $5\frac{1}{2}$ ins.) must be cut to form the projections or lugs carried out at each end with which to make the connections. We get fourteen



such pieces from each sheet. The condenser is built up in this way—and it may be noted that a warm room rather facilitates the work—*e.g.*, upon a table set out a flat board, and on this lay a piece of thin mahogany (fretwork wood) 15 ins. by 8 ins. Now upon this place three or four sheets of the waxed paper, one at a time, and carefully pressing or ironing them down into contact with the thin board by means of a domestic iron or a large "plaster spatula" (as used by druggists); the iron must be kept hot during the whole operation. If the latter instrument is available, it is possible to get it with the flat iron part (as a matter of fact it is made of brass) hollow and the top drilled with a number of holes, the handle being provided with an india-rubber tube for attachment to the nearest gas bracket; this spatula is kept at any desired temperature, and is very useful for the present purpose.

To resume. Having ironed down the few layers of waxed paper, a sheet of the foil is placed in position (there will be a half inch space all round), then to the right hand side is placed one of the small extension pieces or lugs, so that it hangs out a couple of inches or so. Now lay upon the foil two sheets of waxed paper and iron them into close contact, using some pressure in the operation. A second foil is put as before and a second lug—this time to the left. Then two more sheets of paper, another foil and lug to the right; and so on right and left alternately—two waxed paper sheets interposing until the whole of the seventy tinfoil sheets have been built up.

There should be, of course, thirty-five lugs to the right, and the same number to the left. Finish off the condenser by ironing down any of the paper sheets remaining and press down the second piece

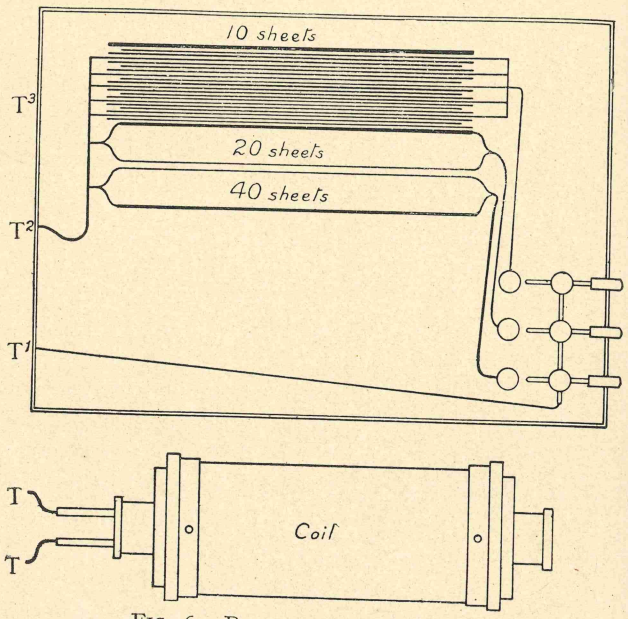



FIG. 6.—PLAN OF CONDENSER.

of the fretwood, 13 ins. by 8 ins., finally binding the whole together tightly with tape.

Condensers are more effective when made as solid as possible—*i.e.*, by means of heat and pressure. Very considerable pressure may be brought into use if one has a letter press large enough for the



purpose. All the heavy weight available will doubtless be used in most cases, but unless some degree of heat is applied at the time of the pressure no even consolidation results. On the whole the amateur will not succeed badly by following the method described, using the iron with heavy hand pressure, and after every six layers, say, subjecting the whole to as much top weight as can be got into play.

The condenser consists of seventy sheets of foil, and there will be thirty-five lugs or extension pieces projecting from either end. Those at one end should be joined together by clamping right across them a piece of strip brass previously drilled in two or three places. The strip is screwed down to the thin baseboard through the foil and holds them firmly in position and contact. To the brass strip may now be soldered a piece of copper wire (about 2 ft. or so).

At the other end, separate the lugs into respectively, five, ten, and twenty bundles, taking care to insulate one set from the next by three or four folds of the waxed blotting-paper. Prepare three lengths (about 12 ins.) of silk-covered lamp wire : the thickly covered insulated twin wire used in installations will do, and one strand is required for each of the sets. Carefully bare the ends of each, preserving the fine copper wires intact : one end should be bared for at least 2 ins. Now, having the wires ready, spread out the bottom pile of projecting lugs—these had better be the twenty—and fold

tightly one of the bared wires right up to the silk covering, cover the whole with strips of waxed blotting-paper; perform the same operation with the remaining sets of ten and five. This end of the condenser may be made fairly solid by successive strips of waxed paper and by pouring a few teaspoonfuls of hot paraffin wax wherever necessary to ensure solidity. When finished there will be three well insulated wires ready for adjustment to the proper terminals on the baseboard of coil, and projecting from one end; and one wire only from the other. The annexed diagram shows (viewed from below) how the condenser is fitted into the base and connected up for use. It will be seen, of course, that the condenser can be coupled up as ten, twenty, and forty sheets respectively. The diagram (Fig. 6) shows the connections as viewed from underneath; by turning the page, therefore, and looking at the figure by transmitted light, placing also the coil over the condenser, we see exactly how the connections are made—to three stout battery terminals fixed in the end of the box.

By manipulating the pins—drawn out in diagram—we can use ten, twenty, thirty, forty, fifty, sixty, or the whole seventy sheets of tinfoil.

Instead of having the twenty, ten, and five lugs respectively on top of each other, but well insulated, they may be when building up, placed as in the diagram, where, for the sake of clearness, they are shown spaced out at the end of the condenser.

## CHAPTER VI.

### THE COMMUTATOR.

IN a photograph (to be reproduced in a future chapter) representing the break and commutator, the close observer will discover an important modification—and improvement—of the Wheatstone design. The usual handle is done away with—there is one contact the less—and the design is stronger and more compact. A reference to the diagram (Fig. 7) will make the construction perfectly clear. The usual hard wood block—boxwood preferred, if ebonite is not at hand—is turned out, the size being not less than 1½ by 1¼ ins.; the standards, A, A, may be cut out of ⅛-in. sheet brass; the side pieces S, S—to the shape figured—are of 1/16-in. sheet brass.

At the end of one of these, having determined the length by bending and fitting it to the block, an ⅛-in. hole is drilled and tapped—a thread also being put on the end of a piece of stout brass rod (1½ ins. or so). This is screwed tightly in and soldered, the threaded end passing right through the strip, as shown in Fig. 7 on next page. Provision is made for it in the block by drilling a small hole,

The other end of this rod should be of a size to take the celluloid or ebonite handle, H; these handles may be bought at any motor-cycle works.

It is, of course, most important to have the standards or brackets quite true and square. A round-headed brass screw, not too long, through the ends, secures the side strips and brackets, and

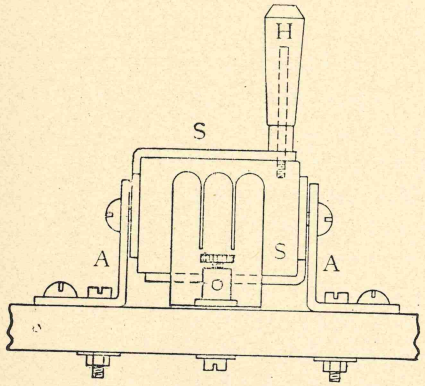



FIG. 7.

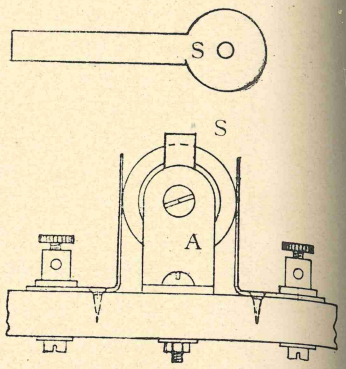



FIG. 8.

CONSTRUCTION OF THE COMMUTATOR

proper contact is ensured. The work must be done accurately, so that the commutator turns rather stiffly but without any shake or unevenness. The side springs present no new features, they should be strong and press evenly upon the side strips; as these strips are of good width and filed up square the commutator practically locks itself on being turned to the right or left.

Fig. 8 gives a clear view of the springs and the



method of fixing them. Stout terminals should be used to make the necessary connections and to give an impression of solidity.

The hard wood block should, previously to fixing, be soaked well in hot paraffin wax.

In place of screwing a piece of brass rod into the end of one of the S pieces for the handle, this piece may be cut longer, bent up, and filed to make a tight fit.

## CHAPTER VII.

### Discharging Pillars and Rods.

A good pair of dischargers may be easily fitted up as follows: Procure two brass gas sockets (sold by most ironmongers) of the shape and size figured (Fig. 9), a piece of ebonite rod (18 ins.) to fit the above tightly; a piece of brass tube, which also must fit tightly the ebonite rod; a small piece of sheet brass about 1-16th in. thick; two large

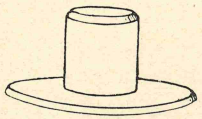


Fig. 9.—Brass Socket.

terminals with pointed or straight screws; and half a dozen small copper or brass picture rings.

Firstly, cut the rod into two pieces of equal length and fit into the two brass sockets. Now to make the brass caps, cut two pieces of the tubing 1 in. long, and file up square; scribe out two circles out of the sheet brass and cut them approximately to fit the collars just made; solder



one to each and file up to make a neat finish. When scribing out, drill a small hole to start from, and this gives us the centre of the cap. Now the pillars may be mounted, each in its socket and capped between the centres of the lathe (a cheap lathe will answer for nearly all the work connected with coil making), and while revolving there the ebonite may be polished, after treatment with rough and fine sand-paper, with putty powder (oxide of tin) and sweet oil, and the brass work finished off nicely with fine emery paper. It is desirable to have the ebonite pillars a tight fit and rigid as possible; before finally screwing them into the sockets, a little celluloid varnish (made by dissolving some small pieces of celluloid in acetone or amyl-acetate) may be applied, or failing this a little seccotine or shellac varnish made rather strong and thick.

Next remove the caps and open out the centre hole to fit the terminal screws, replace the caps, drill holes approximately to size and screw in the terminals; they should closely press on the caps. Place a brass rod through the terminals temporarily, and while there drill a small hole on each side of the cap—at right angles to the rod and about half-way down the cap—and insert a ring, as sold for picture frames. A piece of the screw will have to be cut off. The ring should go close to the cap, and the fit or contact should be good; if at all loose, a little solder should be applied. The pillars may be once more put in the lathe (first removing the top binding screws) and once more polished.

Rubber-covered "low tension wire," to be had from dealers in motor sundries or at almost any garage and repairing shop, is very useful and suitable for the purpose of making the necessary connections; small brass spring clips are attached to bared ends of the wires, and these not only make good contact, but are easily put on the rings and removed.

The discharger rods will be made out of stout brass rods and be a neat fit through the terminals; make them as straight and as highly polished as possible; one at least must be brought to a fine point, while the other should terminate in a turned and polished metal disc about 2 ins. diameter. It is a good plan to bring both rods to a point and to make the other small accessories—disc and brass balls—so that they can be slipped on easily for various experiments with the spark. A short piece of brass tube may, for instance, be soldered centrally to the back of the disc and other pieces to any balls used. These tubes should also be neatly finished and polished, and fit on the discharging rods closely.

Short pieces of ebonite tube—a tight fit on the rods—serve as handles, and, when nicely polished, give a neat finish. They will be more for ornament than for use, as they will not be thick enough to save the operator from a painful shock if he attempts to regulate the distance between the points while the coil is at work.

## CHAPTER VIII.

### Breaks.

Of all breaks actuated by the magnetism of the core, none is apparently so efficient and satisfactory as the "Vril." Another good break is of the "Apps"

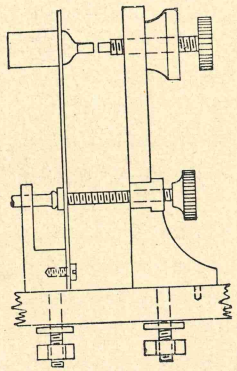


Fig. 10.—Diagram of "Apps" Break.

pattern (Fig. 10); this can be made by the amateur or purchased for a small sum, the price rising considerably, however, if—as should be the case—large platinum contacts are inserted.

Fig. 11 is a diagram of the "Vril" break (not drawn to scale). There are two springs; one carries the hammer head with a double-cranked extension, and the other the platinum stud. The current passes through this stud from the platinum-tipped screw at F, and it is only when the armature has travelled a certain distance (controlled by the screw)

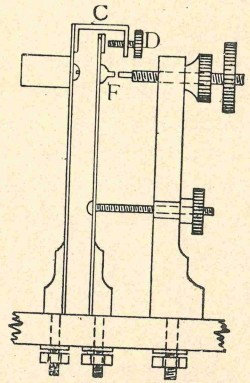



FIG. 11.—DIAGRAM OF "VRIL" BREAK.

that contact is broken by the extension piece catching the contact spring and pulling it away from F. The core has plenty of time in which to get magnetised, and the break when it comes may be aptly termed staccato. It is almost essential to use a rheostat in conjunction with the "Vril" break.

In view of the heavy current which has to be transmitted the platinum contacts should be massive, No. 12 S.W.G. wire is the smallest that should



be used; the pillars and fittings generally also should be heavy and firmly fixed. Where the contact break fitted to the coil is of the above pattern and not intended to be removable—*i.e*, on a separate base—it is a good plan, in view of trials with a mercury break, to fix underneath the pillars thin strips of sheet copper or brass, about 2 ins long by $\frac{1}{2}$ in. wide, to be screwed down to the base parallel with each other with a stout terminal securely fixed to the end of each. When the mercury break is used the platinum contacts of the fixed break should be separated by means of a piece of stout cardboard; then wires are inserted in the terminals referred to and connected the one to the mercury in the cup and the other to the mechanism of the dipping wire.

The aim of all inventors of "breaks" is to ensure the maximum of current passing through the turns of wire surrounding the core, together with a sudden cessation or break in the same, as it is at "break" that the full length of spark is obtained. Either of the breaks just mentioned are efficient for work with the *X*-rays, as they work rapidly, and there is consequently less flicker in the tube; the fluorescent screen is also very steadily illuminated, but the spark length may be greatly increased by almost any well-made mercury break. It is also found that the speed of these can be regulated with greater certainty, especially those operated by means of an electro motor worked from a separate battery. For some reason difficult to find the amateur fights

shy of the mercury break—a strange fact, considering that this is after all the easiest to make, and, if spark length be desired, one of the best. It is very desirable that in making contact the apposition of the surfaces should be long enough to ensure complete magnetism of the core, also that the "break" should be sudden—it is at the latter phase of the operation that we get the spark.

In the ordinary hammer break as commonly fitted this comparatively prolonged "make" is not entirely satisfactory; there is considerable heat generated at the contacts; these get worn and rough, and the contact becomes less perfect after every run of work; nothing but constant filing or hammering to get a smooth surface suffices to ensure the break working with anything like reasonable efficiency. The problem of making contact at speed with a wire connected on one side with a battery and a small bath of mercury in a metal cup and in electrical contact with one of the primary wires of the coil on the other is not one of very immense difficulty, and either of the breaks shown (Fig. 12 and Fig. 18) will be found equal to what is said of them. Fig 12 is a mercury break, the moving principle of which is a bell magnet. The armature must, however, be strong and stiff. It may be easily made from the sketches provided herewith. The *desiderata* are, a rapid movement of the armature and a length of arc sufficient to carry the dipping wire well in and out of the cup; the cup containing the mercury also must be fitted

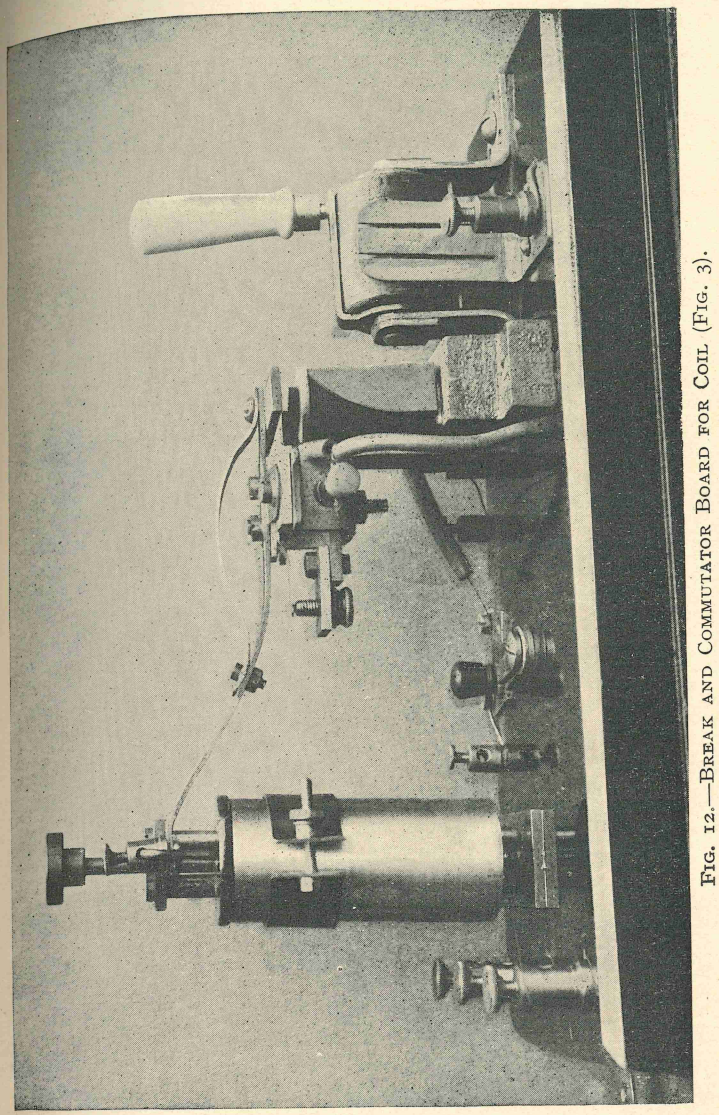


FIG. 12.—BREAK AND COMMUTATOR BOARD FOR COIL (FIG. 3).

strange fact, considering
asiest to make, and, if
of the best. It is very
act the apposition of the
ugh to ensure complete
so that the "break"
he latter phase of the
k.

break as commonly
prolonged "make"
there is considerable
acts; these get worn
becomes less perfect
nothing but constant
smooth surface suffices
g with anything like
problem of making
ire connected on one
mall bath of mercury
al contact with one of
n the other is not one
d either of the breaks
will be found equal
12 is a mercury break,
is a bell magnet. The
strong and stiff. It
he sketches provided
, a rapid movement
h of arc sufficient to
and out of the cup;
y also must be fitted

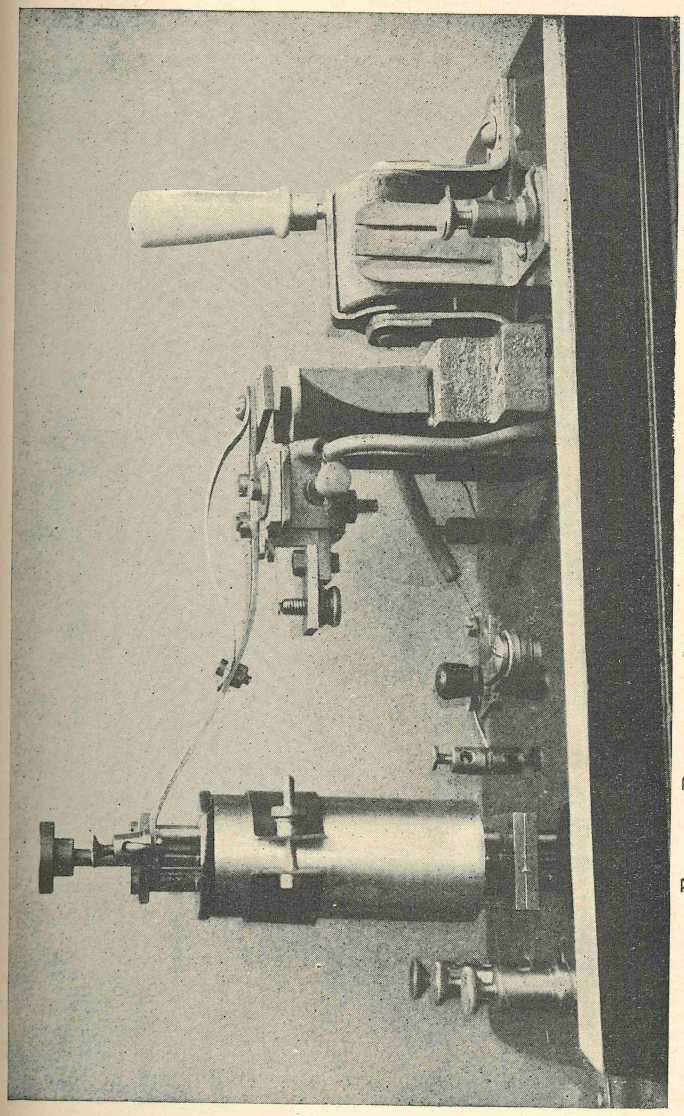


FIG. 12.—BREAK AND COMMUTATOR BOARD FOR COIL (FIG. 3).

in such manner that it may be raised or lowered to the extent of $\frac{1}{2}$ in. at least. The contacts from an old electric bell will serve if made of platinum, and most of the old and heavier class of bell answer this description. Thus, for a very trifling sum, the amateur may purchase a good magnet and contacts suitable for his purpose.

In Fig. 13 the bent piece A is screwed to a block of wood carrying the magnets (see Figs. 13 and 16). The curved bracket at right angles to A is $2\frac{1}{2}$ ins.

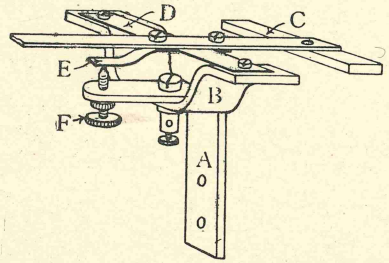



FIG. 13.—BRACKET FOR MERCURY BREAK.

from end to end; it is secured strongly to A by a terminal as shown. The two pieces are insulated one from the other by means of an ebonite bush and washer, but the terminal itself is in electrical contact with A. C is the armature and spring; the soft iron piece might be a little thicker with advantage; the spring, however, must be strong; it may be made out of $\frac{1}{16}$ sheet hard brass. D is the distinguishing feature of this break. It is a piece of broad clock spring; and, therefore, of



considerable tension. It is shown in the diagram as drilled through at each end, and fixed to the bracket by a screw and nut. This was to simplify the sketch. The best way is to fix small brass plates to each

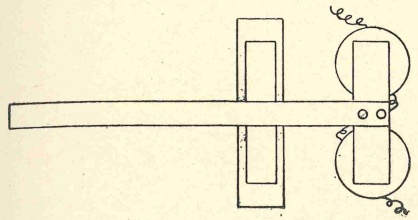


FIG. 14.

end of the bracket and to have the spring just long enough to pass under, when by screwing up the plates it is securely held; the armature spring is also securely held centrally by small nuts and bolts

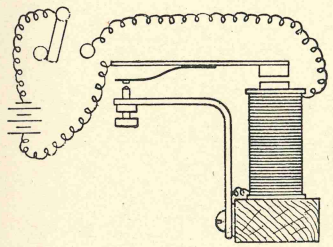


FIG. 15.

and a brass plate under, the spring D passing between them. Before finally screwing up this plate the contact E should be placed under the front nut. The contact F must be arranged as shown

at the end of A. Having provided a couple of dry cells, the break is connected in the usual way. One free end of the wire in the magnet goes to the switch, thence to the battery; thence from the other terminal of battery to B and E, through F and A, which is connected to the other magnet wire.

The diagrams, Figs. 14 and 15, are given to further simplify the matter.

The dipping wire adjusted in a small terminal at the end of the armature, is made of No. 12 S.W.G.

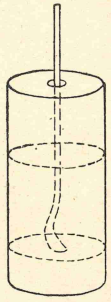


FIG. 16.—DETAILS OF MERCURY BREAK

copper wire; the end dipping into the mercury may be pointed, but it is better when hammered to a broad knife edge and the shape shown (Fig. 16); the edge must be in a perfect line with the "dip," or a great deal of splashing will result.

Fig. 17 is the regulating holder for the cup containing the mercury, which is thus raised or lowered at pleasure by means of the ebonite-milled head. The cup itself is made out of bicycle tubing



of the largest size—a piece is sawn off (4-in.), filed and cleaned and polished, and one end blocked

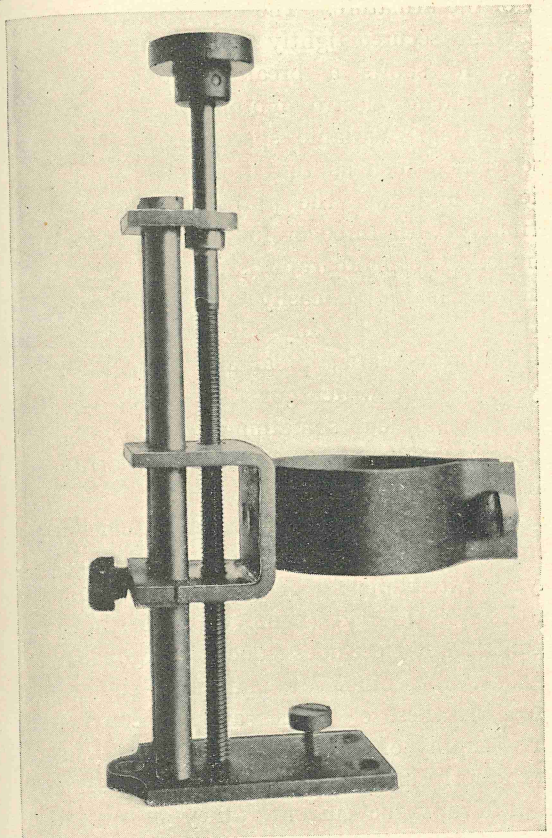


FIG. 17.—REGULATOR FOR MERCURY CUP.

up with a wooden disc cemented in with shellac varnish. The top end should be fitted with an

ebonite cap with centre hole rather larger than the dipping rod attached to the terminal on the end of the armature. The cup is held in the spring collar and secured tightly with a nut and bolt.

Fig. 18 shows a break actuated by a very efficient little electro motor (tripolar armature), self starting. Variable speed is got by inserting a resistance such as thin iron wire, 2 or 3 ft. of which will answer the purpose. The motor runs splendidly with three or four volts and only takes 2 amps. The photograph is so clear that the construction may be easily understood, the only feature representing any difficulty in the making will be the regulating pillar and screw for the mercury cup. The writer got these made for him by a professional, but something could be done with a rack and pinion or screw focussing arrangement, such as are used on cameras.

Other breaks of unquestionable efficiency are briefly described here—viz., the "Wehnelt Electrolytic Interrupter." A glass vessel filled with dilute sulphuric acid (1 oz. to 10 ozs. of water), contains two electrodes—one a large lead plate electrode, the other of platinum—adjustable, of course. If these electrodes are connected with an electric supply of about 40 volts, electrolysis causes gases to form on the platinum; these gases cover it and interrupt the current; they in turn are exploded by the current which in other breaks goes to charge the conductor; the acid then reaches the platinum again and the current is closed once

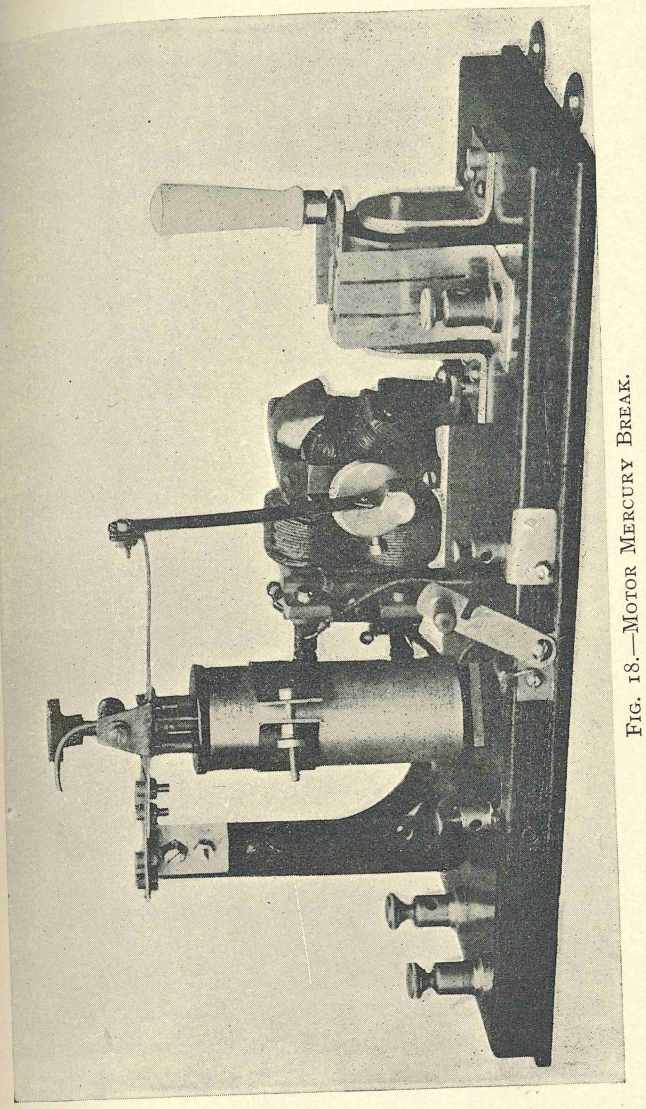


FIG. 18.—MOTOR MERCURY BREAK.

ntre hole rather larger than
ached to the terminal on the
The cup is held in the spring
htly with a nut and bolt.
break actuated by a very
motor (tripolar armature),
le speed is got by inserting
thin iron wire, 2 or 3 ft. of
ne purpose. The motor runs
or four volts and only takes
raph is so clear that the con-
easily understood, the only
any difficulty in the making
pillar and screw for the mer-
got these made for him by
mething could be done with
screw focussing arrangement,
neras.
nquestionable efficiency are
—viz., the "Wehnelt Elec-
A glass vessel filled with
(1 oz. to 10 ozs. of water),
es—one a large lead plate
of platinum—adjustable, of
rodes are connected with an
t 40 volts, electrolysis causes
latinum; these gases cover it
rent; they in turn are ex-
which in other breaks goes
tor; the acid then reaches
d the current is closed once

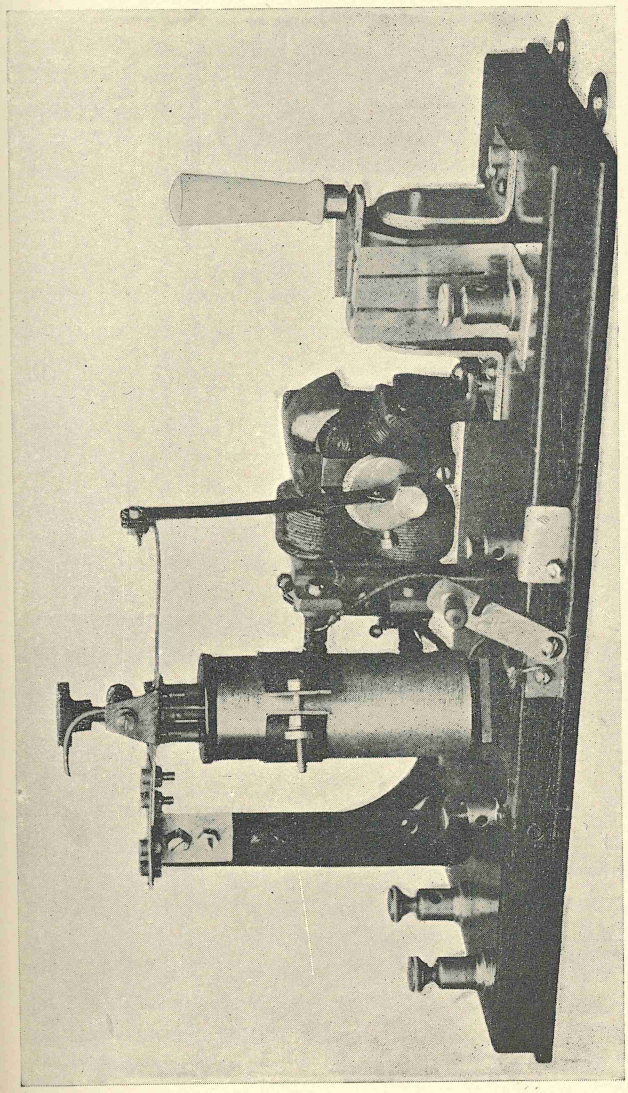


FIG. 18.—MOTOR MERCURY BREAK.

more. This occurs with marvellous rapidity, and the spark attained is extraordinary, being more in the nature of a flame. With this break the condenser is, of course, cut out.

Dr. Mackenzie Davidson constructed a motor interrupter which is deservedly popular. The motor is fixed in a slanting position on a raised platform, and the prolonged shaft carrying the armature terminates in a two-bladed fan-shaped dipper. The lower part of the disc revolves in a bath of mercury, the current being made and broken by the revolutions of the motor. The speed of the motor is regulated by a rheostat, and this speed must be adapted to the E.M.F. used in the primary circuit—when running slowly, from 12 to 20 volts, say, for a 10-in. coil. When running at speed a higher E.M.F. may be used without danger or overheating the primary. With a large coil and 50 volts the spark is of the flaming type, as in Wehnelt's interrupter.

The "Turbine" interrupter is by a consensus of opinion by far the best from the point of view of all-round results. "The sparks obtained from a coil connected with this interrupter are more intense than the sparks obtained with any other interrupter under otherwise similar conditions. The rapidity of the interruptions is perfectly under control and can be varied to any extent. The best photographs are obtainable with this break and an absolutely steady light can be obtained on the screen."—SCHALL.



The plan has been adopted and is recommended of having the break and commutator on a separate polished baseboard. (See Figs. 12 and 18; also shown in the diagrams, Figs. 19 and 20.)

The photograph (Fig. 21) is that of a portable switchboard used by the writer for ordinary work with the coil (Fig. 2), or others built on the same principle.

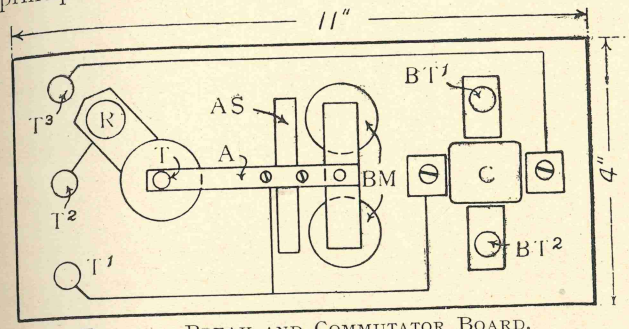



FIG. 19.—BREAK AND COMMUTATOR BOARD.
C, Commutator; BT, Battery Terminals; BM, Bell Magnets; A, Armature; AS, Armature Spring; R, Regulating Screw for Mercury Cup; T, Terminal holding Dipping Rod; $T^1$, $T^2$, $T^3$, Terminals to connect to Coil.

The baseboard and the back are made of 1-in. mahogany and the design is simple but solid. Width, 16 ins.; depth, 9 ins.; height (to top of lamp bracket), 18 ins.

The break and commutator board (Fig. 19) is prepared by screwing four brass picture frame plates, two at each end (two are seen at the end of Fig. 18); before screwing up the plate nearest to $BT^2$ (Fig. 19) a stout copper wire, or a narrow strip of thin

sheet copper, is passed under it and connected to that terminal (make all connection with No. 12 or 14 soft copper wire, or sheet copper in strips, and solder wherever possible). Four strong brass battery terminals with butterfly nuts are inserted in the baseboard of Fig. 21, being placed so that the board

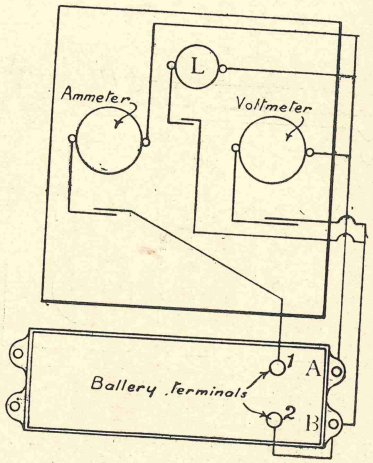



FIG. 20. CONNECTIONS TO SWITCH-BOARD.

(Fig. 19) may be held down firmly. Now, turning to the diagram (Fig. 20) A and B are—under the base—connected to two wires, which are taken through to the back; one of these goes direct to the voltmeter and the other to the switch of same. The lamp is connected similarly. The ammeter is connected in series with the coil and battery; therefore one of its terminals goes to A and the other through the switch to $BT^1$. The battery is then connected to A and $BT^2$.

In use this switchboard is very convenient. The



ammeter must, of course, always be in circuit; in addition to seeing the amount of current passing,

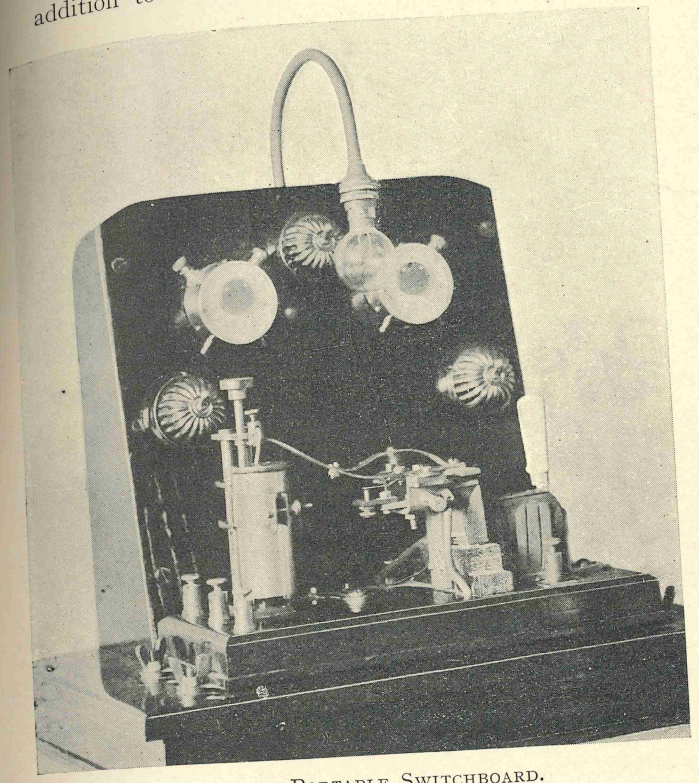


FIG. 21.—PORTABLE SWITCHBOARD.

by switching in the voltmeter, we can at any time test the condition of our battery. The lamp throws sufficient light upon the dials to enable us to easily

read the records given by the respective needles. If the base of switchboard be made big enough it would seem a desirable, safe, and compact place in which to fix the condenser. In this case the coil would be mounted upon a plain polished stand, and would look much lighter. As it is the switchboard is heavy enough for the purpose, but the extra weight of the condenser would be no disadvantage. In the event of the switchboard not being required, the battery terminals are connected to $BT^1$ and $BT^2$, respectively.

It has not been thought necessary to minutely specify the dimensions in every part of the breaks illustrated. The desirable thing is to have them compact. The break (Fig. 12) may be measured practically by comparison with the length of board (11 ins. over all) and the size of the bell magnets, which are quite the usual and common pattern and size. The length of the armature spring may be made adjustable as to length, and it may be strengthened by means of the curved piece seen on the top of it in the photograph, this being designed to give a little increase of tension. The point of the dipping wire should move in and out of the mercury without any supplementary movements of the armature—*i.e.*, springiness is not required. Then the length of the "dip" will depend to some extent on the length of the armature, and the distance between the magnets and the soft iron core; $\frac{1}{4}$ in. is ample—with more than this inordinate splashing results.

# CHAPTER IX.

## The Secondary Winding.

The plan adopted is that suggested by the writer and published in the early part of 1904, with a few modifications, the result partly of experience and partly of environment.

The sketch reproduced from a photograph (Fig. 22) represents the arrangement which has—for several coils—been found very convenient and adaptable.

On the right-hand side of the figure is the driving-wheel. It is a wheel supplied by makers of sewing machines to provide a hand motion in place of the usual treadle, when this change is desired to be applied to existing machines: hence it is a marketable commodity, illustrated in Wheeler & Wilson's list, price 5s. or thereabouts.

For the same sum a small polishing and grinding tool may be bought, which, driven by a pulley from the wheel, serves as "the winder," *i.e.*, the tapered end of the tool fitted with the nut (used ordinarily for the purpose of securing the emery or other grinding disc) is in this case just the very thing wanted to carry the "former" discs, the large brass discs, which in the diagram obscure a full

view of the winder. Still further to the left is the trough in which is melted and kept hot the paraffin wax used, and through which the wire is passed from the bobbin suspended above it—placed conveniently at the back, or, if desired, at the extreme end.

The trough is made of stout tin, and it is well to have it made by a skilled worker in that metal, and it requires to be fairly strong and wax-tight.

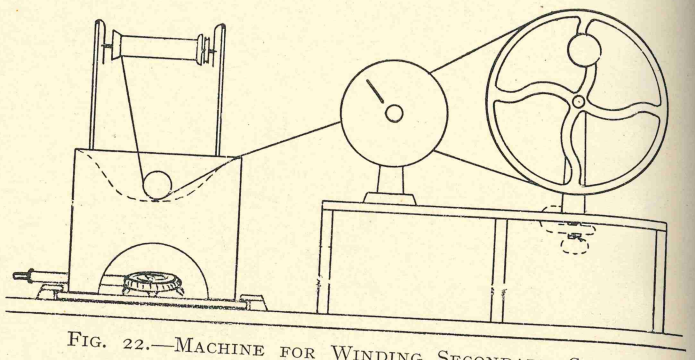


FIG. 22.—MACHINE FOR WINDING SECONDARY COILS.

The dimensions of the one figured are about 9 ins. by 9 ins., the width being $3\frac{1}{2}$ ins., and chosen to accommodate a small gas stove, which may be seen there, or a small spirit lamp. The height is also regulated by that of the spirit lamp or flame used to supply the necessary heat to melt and keep hot the small supply of wax in the trough.

Inside the trough, and near the bottom, is mounted an empty bobbin or reel from the domestic work-box; this is placed on a piece of brass rod, the ends



of which are then soldered to strips of sheet tin, the straps being of such length that, having fixed the positions of the reel, the disengaged ends may be brought up and bent over the sides, where it is advisable to secure them by means of solder.

The skeleton frame to the left and back of the trough is for the purpose of carrying the bobbins of wire. Two pieces of stout brass rod are used (see Fig. 23), one end of each bent over, as clearly seen in the figure; these carry pieces of springy sheet-brass, drilled with suitable holes to carry a

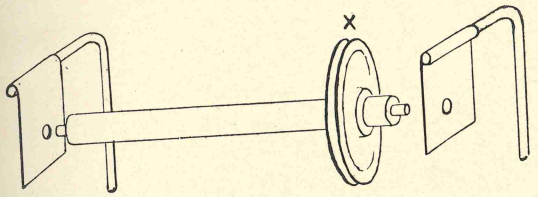


FIG. 23.—WINDING REEL.

spindle on which to slide the bobbins. The distance between the bearings must be rather less than the length of the longest bobbin to be used, as it is intended when the bobbin is mounted on the spindle that the latter should be sprung in in order that some little pressure keeps it in place. This spindle is made by simply measuring off a length of brass rod, placing over it a piece of brass *tube*—a tight fit or soldered, and, at one end, a metal or thin boxwood pulley. The latter, it may be noted, is very useful at times when we wish to empty a few square sections or re-wind on to one bobbin the remainders of several

others; in this case, the bobbin is secured to the side of the pulley by means of a couple of screws; then, if the spindle be mounted on any convenient stand, and a cord put round the pulley, it may be rotated from the driving wheel shown in the figure.

When a full reel of wire—weighing a little over 16 ozs.—is sprung in, there is some little play in the rods; but if made strongly, and so that the brass checks or bearings make decided pressure against the ends of the spindle, there is no trouble, besides which, the weight becomes less as we proceed with the winding—obviously!

The two rods are fixed into a block of wood screwed on the baseboard at the back of the trough, holes being made 2 ins. deep to take them; the rods are also strengthened by soldering them, about half-way down to a strip of stout sheet-brass.

The arrangement possesses these advantages: that the reel is quickly sprung in, or released; that when in place it is in the most convenient position—close to the trough—for winding; that in the event of a break in the wire, which may happen at any time, the left hand is so close to the reel that there is practically no fear of it overrunning; besides which, if the bobbin—just taken from the oven—is placed at a distance, the thin wire is cold before it reaches the trough. A simple arrangement to prevent the risk of overrunning is to put an elastic band over the pulley, a very little tension only of the elastic is required to stop the bobbin in the event of a break in the wire.



The apparatus is designed for an operator working single-handed, and as the whole covers only a space less than 36 ins. by 12 ins., one can stand easily and wind with the right hand while the left guides the wire through the trough and on to the "former." It is mounted on a baseboard—roughly, perhaps—but complete in itself, so that the work may be done in any convenient part of the workroom.

An almost indispensable accessory is a small stove and oven; the writer uses an oil stove of the "Beatrice" pattern, with a small-size oven to fit on the top.

The former discs are made of hard brass, perfectly flat, or turned up true on the face, the diameter being 6 ins.; two are required. In one of these—the back one, we will say—it is suggested to drill two small holes near the edge on the outside and insert and solder two small brass screws, the heads being left out, $\frac{1}{4}$ in. and $\frac{3}{8}$ in. apart. The purpose of these will be seen later; any projection of the screws on the inner side must be filed off and the face made quite smooth.

The other disc—the front one—has a slot cut in it; the simplest way is to draw a line from the circumference to the centre, and then to saw through the line down to a point *equal to the outside diameter of the smallest dividing disc used.* The end of this saw-cut (which must be no wider than absolutely necessary), near the edge of the disc, is now to be filled up with a neat plug of brass and soldered both sides, being then filed up smooth and level.

The dividing discs just mentioned are turned up out of stout brass, or flat sheet-brass, the thickness to be not more than 3-32nds in.; the diameter should be rather larger than that of the ebonite tube provided for the secondary bobbin; in the present case, the ebonite tube provided for the core and primary, and upon which we are to build the secondary winding, is $2\frac{1}{4}$ ins. outside diameter; therefore, the diameter of the smallest pair of dividing discs may be $2\frac{1}{2}$ ins. Three pairs may be made, the first being as stated, the second pair $2\frac{5}{8}$ ins., and the third $2\frac{3}{4}$ ins.; all of them must be very slightly bevelled at the edges—the measurements being taken from the smaller side in each case—and all (together with the large former discs) must have a central hole to make an easy—but not loose—fit over the spindle of the "winder."

It may be remarked here that the annular space left between the ebonite tube and the inner turns of wire may be increased (as proved in other coils) to $\frac{1}{4}$ in. all round, *i.e.*, in the middle of the coil, and up to $\frac{1}{2}$ or $\frac{3}{4}$ in. at the ends, with advantage to the insulation and with no detriment to the efficiency as regards spark length. The above diameters are to be used with cotton winding.

A slight modification of the procedure will follow the use of cotton-covered wire. The apparatus is suited for both cotton and silk-covered. The worker will have to decide at an early stage whether he is going to use silk or cotton-covered wire. Cotton-covered is much easier to wind, but takes up more



room in the sections; the subject is mentioned elsewhere. If a rather bulky looking coil is not objected to, cotton covered wire is just as good as silk. Single cotton-covered was selected for the coil under notice, partly because it was cheap, and partly because it was desired to ascertain how it would compare as part of the finished coil in the matter of efficiency. The term—"rather bulky"—may not after all be the best to use; many professionally made 8 or 9-in. coils are bigger than the one under notice; neither was there any idea of beating a record with regard to "sparking between the terminals," and so on. Not to mention the fact that the secondary terminals are often fixed several inches from the ends of the secondary, and that almost any good coil may be made to spark between its terminals; the main idea was to build a coil at the minimum of expense, which would easily give 8 or 9 ins. of spark—a length, that is to say, quite enough for most users of coils and for most purposes.

To return, however, to the business of winding; if silk or cotton be used, the bobbins are, after thorough desiccation in the oven, or in some warm and dry place for several days, thoroughly saturated with paraffin wax by immersing them in the wax made quite hot, then—after three or four hours' soaking—allowing them to drain. Two or three of the full bobbins of wire should be kept hot in the oven. In the case of cotton-covered wire, the trough is not required, as it is found that the covering absorbs

quite enough wax for the purpose of insulation; another and principal reason is that, if cotton-covered wire is run through the trough straight on to the "former," the latter (the space is only 3-32nds in.) very soon gets blocked up with lumps of cooling, and cold, wax, and this leads to very uneven winding.

Silk-covered, on the other hand, may be run through the hot wax in the trough and direct to the "former" without this happening.

A small accessory remains to be dealt with: This is a small block of wood, one end screwed to the bench, and the other overhanging or projecting. At the end—screwed down—a hole is made large enough to take tightly a 1-oz. wide-mouth bottle (fitted with a cork and small brush). In the bottle is kept the soldering fluid, made by dissolving a few lumps of resin in methylated ether: by placing the section and "former," etc., on the projecting platform, we are better able to get at it all round.

Another useful accessory will be an *un*winder: a spindle with V-shape bearings and provided with a locknut (such as might be used for a circular saw) should be mounted between two bearings. A pair of spare former discs put on the spindle and screwed up then form a receptacle upon which a faulty section can be rewound. Or, the unwinder may be a duplication of the winder—or the most efficient substitute.

# CHAPTER X.

## Waxed Paper Separating Discs.

The discs of waxed paper used in the making and insulation of the double sections are prepared from the quality of blotting-paper known as "Ford 428 Mill." This paper is very free from sizing, and is very dry and absorbent. Testing some good quality ordinary white blotting-paper as sold by stationers, it was found that it contained nearly 10 per cent. of moisture. The brand mentioned may be placed in a warm dry place for a couple of days (as on the drying rack of a large kitchen range) and there is hardly any perceptible decrease of weight. The paper, however, should be as dry as it is possible to make it. Each sheet may then be cut into twelve and the requisite number of squares waxed. Two hundred squares should be prepared by providing a large bath (about 15 by 12 ins.) with a good depth (say, $1\frac{1}{2}$ ins.) of hot melted wax. The bath must be hot and the squares plunged in and completely submerged a few at a time—allowed to remain until thoroughly saturated; then removed one at a time, drained, and, when set, placed in a pile under a moderate weight. It is a good plan to weigh the

squares before and after making. All these little details come to be useful.

For the purpose of cutting the discs the little instrument figured, and sold by most tool merchants under the name of "a washer cutter," is strongly recommended. The "cutter" (Fig. 25), as will be seen, is easily adjusted for any size disc. Two or three of the waxed squares are trimmed at one operation by cutting to an outside diameter of $5\frac{1}{4}$ ins. All the discs must have the outside diameter the

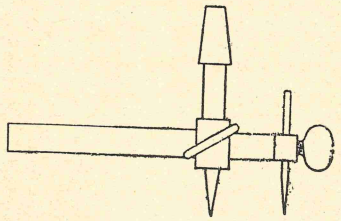


FIG. 25.—DISC CUTTER.

same, but when we turn out the central disc we may vary the diameter by cutting fifty to the exact size of the ebonite tube upon which the sections are to be placed; this will be, in the present case, $2\frac{1}{4}$ ins. The remainder may be all $2\frac{1}{2}$ ins. With just ordinary care the rings of waxed paper are cut out true and very even by this method, but the paper must be waxed first. Of course, there is a trifling waste of wax, which is more than compensated for by the ease with which this part of the preliminary work is got through. (See last paragraph in Chapter II.)



For a purpose shortly to be mentioned a few of the central discs ($2\frac{1}{4}$-in.) cut out should be preserved.

When cutting the circles it is best done by inserting the point in the centre of the paper to be cut, and after pressing in the cutter to revolve the paper.

The blotting-paper discs are very safe insulators. Between each section, or ring of wire, are two of the paper discs, more than ample, it may be, for the purpose. If ordinary white paper, bank post, or good quality demy is used by preference, three or four such discs would have to be used, with no corresponding advantage. The blotting-paper used here absorbs a very high proportion of wax, and keeps very flat and smooth, and gives, no doubt, a good deal of solidity to the coil.

A main feature in successful coil construction is the thorough desiccation of all parts in the building. All paper, for instance, must be as dry as possible before waxing. It is to be said of the brand of blotting-paper recommended that it is essentially a dry paper, and it loses very little weight when placed in a drying closet, and if left out does not appear to absorb moisture; however, the fact remains that it cannot be too dry. It may be further mentioned that "Ford Mill 428" is made in three thicknesses; that used by the writer is "medium."

## CHAPTER XI.

### The Operation of Winding Double Sections.

Having all ready for work—*i.e.*,

1, a supply of blotting-paper discs; 2, the wax melted in the trough; 3, the bobbins of cotton-covered wire in the oven; 4, the reels of cotton; 5, the gas stove flame adjusted so that a soldering iron may be kept in readiness; 6, the plaster iron or spatula also kept hot; 7, the soldering fluid ready with small brush; and 8, the insulating silk—

all in convenient places, we commence by slightly warming the "former" discs.

As a small supply of hot melted wax is in constant requisition the trough is a convenient place to keep it in, even though the wire—unless silk-covered—is not run through it.

Place the large disc—the one already referred to as the back disc—on the spindle of the "winder"; next adjust a central dividing disc thereon with the larger side in contact with the back: we may commence with the largest of the centre discs, *i.e.*, $2\frac{3}{4}$ ins.



diameter, then place the front disc on the spindle and screw up tightly. It will be seen, of course, that the driving wheel and pulley are adjusted properly.

Now remove a bobbin of the cotton from the oven mount it in the skeleton frame, bring the free end of the cotton down and pass it under the reel in the trough, through the hot wax, and so on to the former; thread the end through the slot, and give it a few turns round the spindle. Now, turning the driving wheel and guiding the cotton with the left hand, run the cotton in to a depth of $\frac{1}{4}$ in.—it is easy to see this depth through the narrow slit—cut the cotton and with a thin piece of celluloid—a flat foot-rule of almost exactly the right thickness may be had in celluloid for a few pence—smooth down the cotton in the former; the flat rule also removes any superfluous wax which may have got into the former at the circumference. Replace the cotton in the oven and take out a bobbin of the cotton-covered wire (it should be fairly hot, *i.e.*, in a melting condition), mount it in the frame and bring out the free end of the wire, pass it straight through the slot in the front disc, give it a few turns round the spindle, and commence to wind, turning the driving wheel in the usual way from left to right. There is no necessity to be ultra-careful with regard to speed, and although an even tension should be kept on the wire, it is best to let it form itself into even layers; any attempt to compass this one-self is most likely to result in unevenness. Having wound to the depth required, and, as this double

section is one of those intended for the ends of the secondary, it should not—preserving our scheme of a slight curvature of the secondary bobbin—be wound quite so full as those intended for the middle of the coil. Arrived, say, to a depth of $\frac{3}{4}$ in., stop the winding, cut the wire and, taking the finishing end over the back disc, give it a turn or two round the two screw heads fixed there. If the wire is run in too fast, there is sure to be considerable splashing of wax and, with cotton-covered wire especially, this may become serious, causing an unevenness of the layers and less space for the turns of wire. To prevent this happening it is suggested to run the wire (especially if this be run through the trough) through a small folded piece of lint or soft rag held between the finger and thumb just at the entrance to the channel between the "former" discs. It is most important to get a full average number of turns of wire in each section, otherwise the spark length will assuredly not be up to the specification.

Remove the bobbin of wire and replace in the oven. Now unwind the end of wire which was put round the spindle and bring it out straight; also unwind the end of cotton, but this may be cut where it emerges from the slot, then carefully unscrew the nut binding the former discs on the winder and, withdrawing gently, place it face up on the projecting piece of stout wood referred to previously.

The former now lies flat on the board with the front disc face up, an end of wire projecting from the slot; having a thin blunt knife at hand and



slightly warm, gently and tentatively insert this between the annulus or ring of wire and the top disc. As a rule, however, the knife will not be required, as the metal disc, unless too warm to start with, will come away without any difficulty. Care is taken not to disturb the layer of wire connected with the free end sticking out from the slot. The top disc removed (and to save time it may be placed in a warm place—on the top of the oven, for instance), the flat ring or annulus of wire is in view. First the ring of cotton surrounding the central disc, then the greater depth of wire outside the cotton: the commencing end comes up just outside the layer of cotton and the finishing end is secured to the two screws well out of the way. Thus one section is complete.

Taking two of the blotting-paper discs with the central hole $2\frac{1}{2}$ ins., one of these is carefully adjusted on the top of the wire, bringing the free end through a small hole made with a pin close to the edge of the aperture, the blotting-paper disc being then adjusted carefully so that the centre aperture is evenly placed on the brass dividing disc. There will not be much room, but it should press evenly all round; then the second disc is put down in the same way, bringing the wire through as before. By means of the hot iron the paper disc is pressed into contact with the wire, being careful that the pressure is evenly distributed. The pressure indeed must be kept up—by using a spare former disc or other flat metal surface—until the wax has set hard.

Now, a washer is to be made of double thickness blotting-paper, rather smaller than the circle to be covered, and a hole made in it; place this washer on the brass dividing disc, and then adjusting first the duplicate dividing disc (the same size as that first used, this time with the wider side uppermost) and the outside former disc, replace on the spindle and screw up. This little operation being carefully done, we have now in the former one side filled with wire—one section—and a wall of insulating material between this and the front disc, a clear open space of the same width as the first with the free end of wire from the first layer of the section now hanging from the inside of the "former." This end, however, must be brought up and fixed to the two screws for a few minutes, as the second section has to be wound with the same depth of cotton as the first. This carefully done, the wire is once more disengaged and the end bared.

Replacing one of the bobbins of wire on the skeleton frame, the free end is bared and joined to that from the former; a joint of $\frac{1}{4}$ in. is ample, and it should be made by twisting, then touched with the brush from the bottle of resin solution and the soldering iron applied: the right heat being attained for the latter, and with a small quantity of solder a perfect union of the two bare ends is achieved. The joint should be trimmed of any little bits of surplus wire ends, taking care that these do not by any mischance fly off into the former, where by getting between layers of wire they would infallibly result



in damage. The free end of wire from the former being several inches in length—it may be any convenient length—the joint will be made well away from the "former," in full view, and in the easiest possible manner. The joint is properly insulated, with a small piece of the thin waxed silk ribbon warmed and pressed round it.

Now, turning the driving wheel the reverse way, wind the first few turns in slowly, being careful not to lose sight of the joint until it is seen to be evenly bedded in its layer and its silk covering intact. The celluloid rule may be used again to gently press these first few turns; if this is not done, the layer with the joint in it may be a little above the level, and result in the section getting out of the circular shape. All being satisfactory the winding is proceeded with faster, and the wire run in to the same height as in the first section. We finish off at or near where the first was finished, cut the wire and (having released the free end of wire of the first) twist the two temporarily together. It may now be seen that we have a complete pair of sections with the wire running in one direction throughout.

Unscrew the nut binding the former, remove to the bench and release the top disc. The first central disc in view is to be carefully lifted out without disturbing the cotton; it may be warmed a little if necessary, then replacing the large disc for a moment, turn the "former" over and with a blunt knife (rarely necessary) remove the back disc, and the second dividing disc. The appearance pre-

sented now is that of two flat rings of wire mounted and insulated one from the other by a pair of blotting-paper discs. In this condition it is possible they may take no harm if carefully folded in paper or enclosed in an envelope, but, as a matter of fact, it is better (after running a little hot wax all round the edges) to fix one of the single paper discs to each side by means of the hot iron, using pressure till set in each case, as when fixing the central disc. One of these blotting-paper discs should be from the set made, of which the central aperture is exact size of the ebonite tube, and the other from the set aperture $2\frac{1}{4}$ ins.

The double section is now finished so far as it is requisite to go. It is a question, however, whether the work is not further improved and strengthened by returning the pair of sections to the former and while held there filling up the space between the last layer of wire on each side and the top of the blotting-paper discs with cotton, thoroughly dried and waxed and run in hot. All these spaces require to be, when the sections are mounted on the tube, filled in and completely covered with wax, and the procedure with cotton is a half-way step. The sections treated in this way look extremely well, and the winding and insulation could not be improved upon. The author does not say that it is necessary, but it certainly strengthens the ring of wire and gives it a very good finish.

It will be seen from the sectional drawing of the coil (Fig. 3) that the double sections fitted near the



ends contain rather less wire than those in the middle, or, put another way, there is a greater depth of insulation, cotton, etc., near the ends, *e.g.*—four pairs of sections will be required with a $\frac{1}{4}$ in. depth of cotton winding, and six pairs (using the middle size of dividing discs) with $\frac{1}{8}$ in. of the same ; all the remainder may be from the smallest of the discs. but *all* should have $\frac{1}{8}$ in. of the cotton insulation. The operation of winding is, of course, the same in all cases.

It is desirable to ascertain, approximately at any rate, the number of turns of wire in each section.

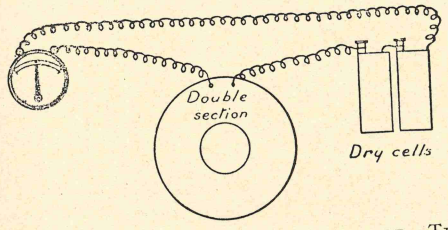



FIG. 26.—DIAGRAM OF CONNECTIONS FOR TESTING SECTIONS.

The simplest way is, naturally, to count the number of revolutions of the driving wheel and multiply by the difference in diameter between it and the pulley ; but a counter may be rigged up to make contact with a rubber pulley screwed on to the other tapered end of the winder, which otherwise would not be used. If the first of the sections wound is counted and the other three are found to be the same weight, we may reasonably conclude that the same number of turns is in each ; similarly with the other sets.

The sections should be weighed and the weight recorded, making full allowance for the blotting-paper separating discs, and finally each pair of sections, when finished, should be at once tested with a galvanometer and a small battery for continuity. This is done by baring both ends of the wire and connecting up as in the figures, and we must not be satisfied with anything less than a decided turn of the needle. A small metal necktie or scarf clip with the serrated edges a good fit is

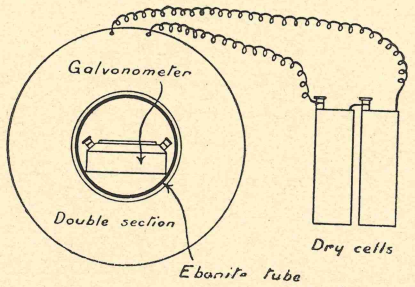



FIG. 27.—ANOTHER METHOD OF TESTING.

useful with which to grip the fine wire, a piece of stouter wire being soldered to the other end of the clip. (Fig. 26.)

A better way of testing is to place the double section vertically over the end of the ebonite tube and the galvanometer within the tube ; or, again, by placing the section flat on the bench and the galvanometer inside the centre opening : on making contact with the battery terminals the needle will swing quite round. (Fig. 27.)



It will be clearly demonstrated by the foregoing that it is impossible to have sections of wire opposing each other, if firstly, we always commence winding the *first* section of each pair *in the same direction*, that is to say, turning the driving wheel in the direction of the clock, from left to right. This, referring to the extended diagram (Fig. 28), gives us *when finished* the first section. It will be remem-

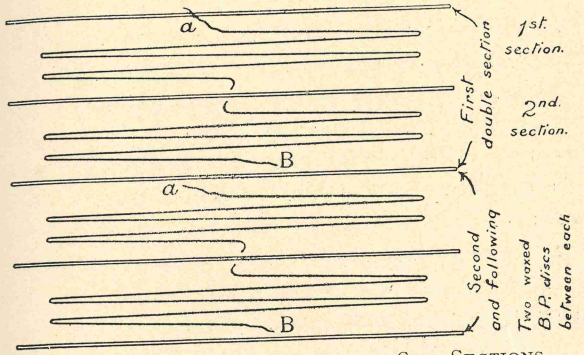



FIG. 28.—EXTENDED DIAGRAM OF COIL SECTIONS.

bered that the wire being put on from the lowest turn upwards looks to be going on the reverse way.

Secondly : The inside end of the first and the beginning of the second being jointed the driving wheel is to be turned from *right to left*. Then, arrived at the level of the first section, we find that the last turn of the second section comes up from the opposite direction. In this position and to *temporarily* complete the pair, these two wires—*a* and B in the figure—are twisted tightly together.

It will be seen, therefore, that any pair will couple up to any other pair, as B to *a*, and we shall get a continuous spiral and winding—*i.e.*, in one direction from end to end.

It is very important to keep an even tension on the wire; loose winding means a considerable loss of space, and is almost sure to lead in the interval between the winding of the section and the fixing of it in position on the coil to a loosening of one or more turns and the possible dropping of these between the section of wire and its blotting-paper washer. The difference of potential between the inside and outside turns is so great that a section wound unevenly with one turn possibly forming a chord of the circle is almost certain to lead to internal leakage. The wire in winding will easily *form itself into layers*; that is no trouble at all; the operator must see that one layer by fairly tight winding runs evenly over the next layer.

## CHAPTER XII.

### Building-Up the Double Sections.

Having wound all the double sections required, tested and weighed them, they should be carefully sorted into piles—*i.e.*, there will be the set of four, the set of six, and the forty for the main body of the secondary. The idea of having the blotting-paper insulating discs of various sizes is to more thoroughly *case in* each pair of sections—*e.g.*, in the enlarged and separated figures three pairs of sections (Fig. 29) are shown: the first being placed on the ebonite tube, fits tightly or closely, because the first or lower insulating disc has its aperture of the same size—viz., 2 ins. We may now fill in the hollow between the cotton and the ebonite tube with hot wax, and upon fixing down the next pair the lower insulating disc will again be a close fit on the tube, as demonstrated in the figure. We have thus a clear space into which to run the wax, and the insulation is further safeguarded by the thickness of the blotting-paper—a close fit—at every fifth of an inch along the tube. In no case, as will be seen, is the wire in one section allowed to come to a level with

the wire in a neighbouring section without the thickness of two blotting-paper discs intervening. This, briefly, is the method adopted in building up the pairs of sections.

It will be convenient to start building the sections from the centre of the tube, and for this purpose we first make a stand—strong and durable—of the pattern as shown in Fig. 30.

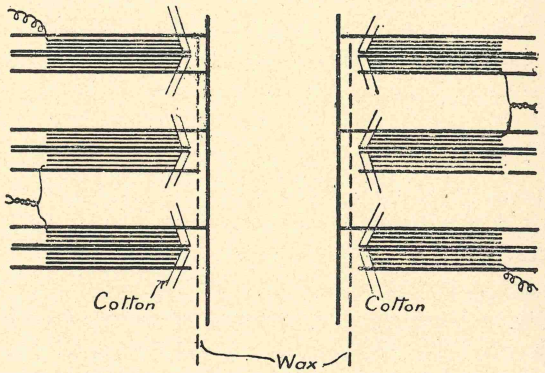



FIG. 29.—BUILDING-UP DOUBLE SECTIONS.

As the top weight is continually increasing, the stand should be made of wood at least 1 in. thick, and the base of it is to be screwed to the bench, using one screw so that the whole may be turned on its axis.

The stand being levelled, the ebonite tube is placed upright in it. The tube should be raised or lowered until exactly one-half of it appears above the top, and after careful adjustment to ensure the tube



being vertical the bottom end may be wedged in in such a manner that this position is retained throughout.

Taking a pair of sections from the pile of forty—it will be better, perhaps, in order to avoid mistakes, to count these into two of twenty each—it is placed over the vertical tube without regard to the

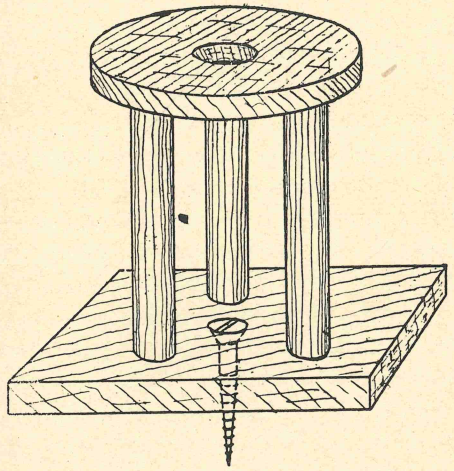


FIG. 30.—STAND FOR BUILDING-UP SECTIONS.

position of the terminating wires. A supply of hot fresh melted paraffin wax is kept ready in a metal cup or small teapot, a metal teaspoon or small ladle is also provided, and a spirit lamp, while the plaster iron must also be kept hot and ready for use. The double section being placed in position, a spoonful of the melted wax is held for a few seconds over the

spirit flame, and when *quite hot* is poured into the space around the ebonite tube between it and the ring of cotton. The wax, if sufficiently hot, will run into the space and entirely fill the interval between the tube and the cotton, there will also be indications of a swelling of the sections at this part denoting that the wax has permeated the interstices and run partly into the turns of wire ; at this time and just before the wax shows signs of setting—which it will do with a good deal of contraction—the hot iron must be applied, when the wax is forced back into the annular space, which then, as the setting continues, will be entirely filled up with the wax, and is to be smoothed down equally all round. The turntable stand will greatly assist this operation, as it is desirable to have the pressure with the hot iron equal all round, otherwise on applying a spirit level after putting down a few sections we may find that the true horizontal position (perhaps from using too much wax) has been departed from ; this can be remedied when only a few sections are in place, but is a serious fault if only discovered on reaching the end of the tube.

If the first double section fits the tube, as it should, *tightly*, by reason of the lower blotting-paper disc having its central aperture the exact size, it is put in place with no more trouble than the others following, but, if desirable, a few spare discs may be temporarily placed down before fixing the section, these preventing the hot wax from running through, and down the tube.



The first section neatly set, the bared ends of the wire are untwisted, the back or lower one left hanging out for a couple of inches or so, but secured by passing it first through a small hole made with a pin near the edge of the insulating disc. The other end is also brought *up* through a hole made in the edge of the top disc, but about 2 ins. distant from the other.

Before fixing the next double section its two wire ends should be treated in the same way—one sticking out near the edge of the back disc, and the other coming up through the edge of the front disc. The second double section is placed loosely on the first, while the connection is made between the first double section and the second. No more wire should be spared for this purpose than is absolutely required for comfortable working, and taking the two bared ends these are twisted together, touched with the resin and ether solution, and a good soldered joint made with similar precautions as suggested previously. When making joint in the sectional winding, the joint must be very carefully insulated with silk and the whole length or loop of wire then encased in a narrow piece of folded waxed blotting-paper ; on slowly turning the loose pair of sections the joint falls with its covering neatly and naturally between the two, not being low down but about $\frac{1}{4}$ in. from the top.

It is the author's practice, before fixing the second pair, to test the continuity of the wire and perfection of the joints by using the galvanometer and

battery immediately after jointing up each pair, and this course is recommended (see Fig. 26).

The second pair of sections is now to be fixed in position with a similar application of hot wax and the hot iron, and the further building up of the coil follows the same way throughout until the whole of the twenty-five pairs of sections are in place, when the ebonite tube is carefully reversed and the building up of the second half proceeded with.

*Each end* of the coil requires very careful finishing. Presuming that all the sections have been fixed, any spare blotting-paper discs—or washers, as we may now term them—may to the number of four or so be ironed down over the first and last section.

In order to facilitate the covering in of all these sections with wax, besides assisting to give solidity to the whole, two discs of thin wood (mahogany) are prepared, $\frac{1}{4}$ in. thick, and $5\frac{1}{2}$ ins. diameter, with a central hole to fit the ebonite tube. With a large centre-bit and brace, holes are drilled in these discs all round the centre hole; they are then dried and soaked in wax, and one is fixed to each end of the secondary winding. The wood discs are severally warmed and pressed down, hot wax being poured into the holes meanwhile; the result is a very close fit. Several heavy weights may be adjusted to exert an even pressure until the wax has thoroughly set.

This done, the two thick ebonite cheeks—each 6 ins. diameter, and with central aperture $2\frac{1}{4}$ ins.—are placed at their respective ends. They should be made very hot, and having applied the hot iron to



the surface of the wooden disc, pouring over it also a teaspoonful or two of hot wax, the ebonite cheek is passed over the end of the tube and pressed heavily into contact with the end—continuing the pressure until the wax and ebonite have cooled and set hard. The ebonite cheek should be in absolute contact with the wood disc.

Objection may be made to the method of connecting up each double section—that is to say, the joint being between two sections, although folded in waxed blotting-paper, might slip down if the pressure was not even and close, thus forming a chord of the circle. The potential difference is so great between the outer and inner turns of wire that the insulation might be threatened. Although no trouble has been met with so far, there is the older plan of bringing out the wires—through the pinholes—opposite each other, and, after baring the ends, twisting them, soldering and insulating the joint with silk after cutting off superfluous wire, then carefully tucking the insulated joint between the pair connected. This method is commonly used, and though a great point is made of the other, there is—it must be admitted—no appreciable difference in practice and results.

## CHAPTER XIII.

### Finishing Off the Coil.

For the purpose of doing this comfortably and without damage to any of the sections, a strong stand should be made of the shape and style as in the figure (31). Wood of 1-in. thickness is required, the distance between the standards being a fraction of an inch longer than the extreme length of the ebonite primary tube. This length for coil described is 17 ins. The uprights should be screwed down and strongly wedged at the back, so that the coil being suspended between them, *pressure* may be exerted if necessary on the secondary by the insertion of wood blocks or other suitable means between the ebonite cheeks and the standards.

Before removing the coil from the upright stand (Fig. 30) procure a length (about 20 ins.) of the stoutest broom handle it is possible to get, and wrap tightly round it some sheets of brown paper (17 ins. wide). Enough of this must be put on to make the wooden rod a reasonably tight fit within the ebonite tube of the coil. The rod must now be passed through the tube, an equal length of wood



being left sticking out at each end. We may now lift the coil off the stand and place it between the standards, the weight of the coil being very well distributed the protruding wood ends resting in the semi-circular holes provided for them. In this position the coil may be rotated, and the outside covering proceeded with.

If the plan be adopted of finishing off each section by several outside turns of cotton, the ring of cotton extending quite or nearly to the extreme edge of

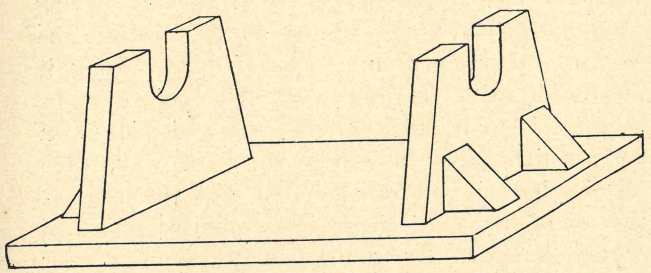


Fig. 31.—Wooden Stand for Use in Finishing Off Coil.

the paper disc, then the covering and finishing of the outside of the secondary bobbin is simplified.

It must be said, however, that a thickness of $\frac{1}{4}$ in. of solid wax outside all the sections, even though these have for the most part been filled in with cotton and wax, is desirable as a precautionary measure against accidental sparking.

First, however, the first and last sections require to be dealt with. It is presumed that the whole of the winding has been tested for continuity and found

correct; then the fine wire ends require to be strengthened, as, for attachment to terminals, etc., the gauge is much too thin if the specification be followed exactly. The fine wire ends are respectively soldered to a length of silk-covered lamp wire—as suggested for use in the fitting of the condenser—*e.g.*, a 2-ft. length of best silk-covered twin wire is untwisted, making two strands, and carefully straightened; the ends are bared, and one in each case soldered to the terminating wires of the coil. Carefully insulate the joint with silk, and, having some hot melted wax ready, lower the wire into the section, taking it round once at least, basting it meanwhile with the hot wax. The object to be attained is to bring up the silk-covered wire clean and straight from a solid section of wax, each terminating wire to be in line one with the other at the top of the coil. These silk-covered wires are, of course, intended for connection to the discharger pillars.

In order to put on the final thin covering of wax we shall find the two thin wood discs, one at each end of the coil and of larger diameter than the blotting-paper discs, extremely useful. Firstly, cut out of thin sheet zinc or tin a piece just large enough to go once round the coil—but the ends should not meet by $\frac{1}{2}$ in. Care must be taken that the sides of this tin cover make accurate contact with the edges of the wooden discs; strong twine, or a few turns of wire, ensure contact here, and a turn or two at intervals along the body of the cover will bring the



same into a circular shape from end to end. The $\frac{1}{2}$-in. opening will be, naturally, at the top where the end wires come through, and is necessary for the purpose of pouring in the hot wax, a good supply of which will be required. It will be gathered that if the cover has been tightly fitted and neatly rounded there will be a space inside all round the sections of $\frac{1}{8}$ in., which is to be filled with wax. By means of a spirit lamp deftly manipulated the metal cover may be kept fairly hot while the hot wax (and it must be *hot*) is being run in. The idea is to allow the wax time to flow into all the interstices, and to gradually cool and solidify outside; and as the wax contracts very much at this stage, constant ladling of fresh hot wax from the top is necessary, and the top part itself—where the opening is—will require to be finished off with a knife or spatula, taking care again to bring the terminal wires neatly and cleanly out of the bed of wax.

When the wax covering has quite cooled and hardened the metal cover is released, and will, as a rule, spring away from the wax, leaving the coil very neatly, and so far, finished.

The usual and final covering of thin ebonite sheet must now be put on. Presuming that the coil, or secondary bobbin, fits cleanly between the outside cheeks, close up as described previously: it will be an easy matter to cut first a shape out of thin cardboard, which should accurately fit the bobbin between the cheeks—and from this a piece of sheet ebonite of the size required. The ebonite is rather brittle,

therefore it should be placed on a perfectly flat surface and the size carefully ruled off. The cutting is done most readily by means of a sharp pointed tool. The edge should be, if necessary, filed up and sandpapered and oiled, and after careful measuring the two holes drilled through which the terminating wires are to pass. The ebonite cover should not quite meet at the edges—it requires to be laced on tightly—therefore a $\frac{1}{4}$ in. space should be left. Also, holes at intervals of $\frac{1}{2}$ in. must be drilled (or made with a red-hot needle) in the sheet at this part to enable this to be done, the series of holes being uniformly $\frac{1}{2}$ in. from the edge. While lacing on the cover, it is advisable to insert a strip of ebonite *under* the lacing the full length of the coil.

Before attempting to put the ebonite sheet round the coil, it must be softened in hot water and bent approximately to the shape. The sheet ebonite softens readily in hot water and may be shaped, and it has the property of retaining the shape given to it on cooling. Having therefore a supply of hot water—it must be really hot—in a dish or tray sufficiently large for the purpose, the ebonite is pushed in edgeways and given a *curve approximately to the circular shape of the coil.* It is a job more troublesome than difficult to give the ebonite an even curve, and it is not desirable at all to make the ends meet, as, if cooling in that condition, the cover would have to be sprung open to admit the coil, and would probably crack. The curve must be such, therefore, that a slight spring only is required



to admit the coil, the silk-covered wires being brought up through the holes drilled for them, the cover being then laced on. The appearance of the coil is further improved by lacing on, outside the ebonite cover, a narrow strip of sheet ebonite at each end—this strip may be seen in the photograph of the coil (Fig. 2).

If it is not intended to have the core readily removable, then the insulation may be further improved after putting the core within the tube, by filling the two ends entirely with hot wax. Even with this additional strength it would not be a very difficult task to remove the core, if found desirable at any time to do so.

Two ebonite caps are now to be fitted to the ends of the tube in order to give a neat and business-like finish. In one of them two holes must be drilled and bushed with pieces of ebonite tube, so that the two primary wires can pass through properly insulated one from the other.

The two standards upon which the weight of the coil permanently rests should, the author thinks, be ebonite. The cost of this article is, however, considerable, and prevents a lavish outlay; but that alone would not have been the reason why hardwood supports were used in the present instance in place of the ebonite.

It was thought that, considering the thickness of the insulation at this part—above all, the fact that the two bobbin cheeks are of ebonite $\frac{1}{2}$ in. thick—a good standard might be almost as effective made out

of selected mahogany or walnut as if made of the more expensive material. The coil might have been mounted on the ebonite cheeks only—with slight modifications in the building up of the secondary—which would have been quite in accordance with precedent. The principal and important objection to this is that the coil is then much too close to the base.

Another point is that if a large coil is constantly worked at its full capacity *the ebonite tube upon which it is built must not be too short.* A fair rule is to have it twice the specified spark length. For instance, Fig. 33 shows a coil which sparks easily 11 inches, but is rarely used at that; otherwise the tube would be extended at the ends, and the insulation there thickened.

It may be recorded here that one may pay a heavy price for "the best" ebonite, and find it after all very imperfect. When vulcanising a mass of rubber it is not an easy matter altogether to avoid faults in the way of air-cells, and these we know nothing of until when filing, or shaping, or turning the hard rubber we suddenly come on a cavity which may spoil the work entirely. This, as a matter of fact, accounts for the two ebonite cheeks being 6 ins. diameter instead of $6\frac{1}{2}$ ins., as designed originally, for, when turning one of the discs, a hole was discovered necessitating the turning down to 6 ins. of both discs to make the pair.

Of course, this is a strong argument in favour of a further insulation in the shape of ebonite standards,



but the author is illogical enough to find the hardwood supports quite reliable. They must be very dry, soaked in paraffin wax, and polished. The centre holes should be $2\frac{1}{4}$ ins. diameter.

The two primary ends projecting at one end and through the cap bushed with ebonite tubes (see Fig. 2) are covered with rubber. Something suitable for this is got by cutting a piece of thick "flexible" line wire, which will be found full of a small gauge wire, which must be removed; the covering serves the purpose we require very well. The primary wires may be carried right through into the condenser box forming the base of coil; but as the author uses a movable core, it is found simpler to bring two wires (No. 14 S.W.G.) up from the terminals and connect them by brass connectors to the ends of the primary. A small block of mahogany, with two stout terminals, might be used, and the wires from the condenser box permanently fixed under them. It is certainly found to be a great advantage to be able to remove the core, and indeed the whole coil, without having to meddle with the mahogany shallow box upon which it stands.

On completion of the work of winding and covering it is natural to wish to see the results of the time and labour one has devoted to the coil as soon as possible.

It is occasionally recommended to test the secondary sections for length of spark, one by one, as added during the building of the coil. This, of course, pre-supposes the existence of break,

condenser, etc., and a ready means of fitting the coil roughly—and on a temporary support—for this particular purpose.

It is doubtful if anything is gained by the procedure. The winding is subjected to repeated tests and strains at a time when it is in quite an unfinished state, and although the result is the visible demonstration of an increased length of spark for every additional section, the total output at the finish, *i.e.*, when the coil has been actually completed, may not be so satisfactory.

The testing of each section as finished for continuity and correct winding is sufficient for all purposes; after covering the coil with wax, but before lacing on the outside ebonite cover, the desire to see results may be legitimately gratified.

Presuming the condenser to be properly secured in the base, and the pins inserted and screwed up so that we have the benefit of the full number of sheets of tinfoil, the coil will be placed on the stand and the primary wires connected as shown (Figs. 5 and 6). The secondary wires from coil are to be connected to the rings provided for them on the discharger pillars, and the discharge rods adjusted to a distance of 3 or 4 ins.

Wires are then adjusted to the three terminals on the end of the base of coil and connected to the three corresponding terminals on the end of break board. The wires are to be parallel one with the other. At the other end of the break board connecting wires are taken to the battery, which should



be one consisting of four cells of the capacity and make suggested in the first chapter, *i.e.*, seven plates, 4 by 4, in each cell. The commutator handle should be in a vertical position until we are ready to turn on the current. The ammeter switch is now to be pressed down so that the ammeter is put in circuit, and we may then—after testing the battery for its E.M.F.—switch on the current (from two dry cells at the back of the switchboard) *to the break*. The cup for the mercury must be screwed tightly and placed low down; 2 ozs. or so of mercury may now be put in and covered to the extent of 1 in. at least with paraffin oil. The dipping wire adjusted in the terminal at the end of the armature arm must be screwed tightly, and must not be too long, as it is necessary to raise the mercury gradually by means of the ebonite milled head of the regulating stand, so that we make the contact tentatively.

Presuming that the break is working satisfactorily, we may now turn down the commutator handle to right or left, and turning the ebonite milled head, raise the mercury cup. As the mercury meets the dipping rod sparks will immediately begin to pass between the points of the dischargers, rather thin at first, but very fat and thick as the mercury cup is slowly raised and the dipping rod makes longer and more full contact with the mercury. It is usually found that the coil sparks better and more freely when the current is flowing in a certain direction.

Now, switching off the current, the dischargers may be separated a little more, and, turning the

current on again, the spark length noted. It is safer *not* to make any adjustment of the discharging rods while the coil is in action; always switch off first. No difficulty should be met with in getting the full specified length of spark by a slight adjustment of the break; and, if the operator has been more than usually careful in his work, the output with one or two additional cells may be very satisfactory.

All the coils illustrated in this manual are amateur work, and the results are very gratifying. These will be described in the next chapter.

A very suitable wire for use in making the connections to battery and from coil to break is the rubber-covered "low-tension wire" used on motor cars, and to be had at any garage.

It is not at all unusual for coil-makers to use for the end sections of secondary a rather larger gauge than for the bulk of the sections; this is for the purpose of more safely carrying the "accumulated electrical discharge," a phenomenon which probably has no real existence.

When testing the sections during its construction for spark length, it will be found that not only is the spark length increased, but that there is an *appearance* of accumulated discharge, the sparks rushing from the fine wire end with a force and commotion akin to the rushing out of water from a house tap; but we surely do not argue from the latter that the force or pressure is greater at the tap than it is anywhere along the pipe itself?

# CHAPTER XIV.

## Some Specifications of Coils.

*Core.*—No. 22 S.W.G. iron wire, $8\frac{1}{2}$ ins. by 1 in.; weight, 1 lb. 4 ozs.; bound with silk ribbons and insulated with shellac, and baked.

*Primary.*—$1\frac{1}{2}$ lbs. No. 14 S.W.G. D.C.C. copper wire, in three layers; length across turns, $7\frac{1}{4}$ ins.

*Secondary.*—5 lbs. No. 36 S.W.G. S.S.C. copper wire, wound in twenty-six double sections; length over sections, $6\frac{1}{2}$ ins.; 36,104 turns.

*Condenser.*—Eighty-four sheets of tinfoil, 8 by 5 ins.

*Primary Tube.*—Ebonite, $\frac{1}{8}$ in. thick; cotton insulation in secondary, $\frac{1}{8}$ to $\frac{1}{4}$ in. at ends.

*With 8 volts 5 amps. above coil gives $6\frac{3}{4}$ ins. continuous spark (G.C.).*

*Core.*—No. 22 S.W.G. iron wire, $\frac{5}{16}$ in. by 12 ins.

*Primary.*—Two layers of No. 14 S.W.G. D.C.C. copper wire.

*Secondary.*—$5\frac{1}{2}$ lbs. No. 36 S.W.G. copper wire S.S.C. in thirty-six double sections, making 46,990 turns round primary.

*Condenser.*—Seventy sheets, 12 by 8 tinfoil; two sheets white demy paraffined paper between each.

Separating discs = three thicknesses pure filter paper.

*Primary Tube.*—Ebonite, $\frac{1}{8}$ in. thick; cotton insulation in secondary, $\frac{1}{8}$ to $\frac{1}{4}$ in. at ends.

*With 8 volts 9 amps. above coil gives $8\frac{3}{4}$ ins. continuous spark (G.C.).*

These two coils should be drawn to scale in order to study their relative proportions.

### Small Spark Coil.

*Core.*—$\frac{3}{4}$-in. by 9-in. No. 22 S.W.G. iron wire.

*Primary.*—Two layers No. 14 S.W.G. D.C.C. wire; dried and waxed.

*Secondary.*—$3\frac{1}{2}$ lbs. No. 36 S.W.G. S.S.C. wire; thirty double sections; waxed paper separating discs (two) between each wire section.

*Condenser.*—Sixty sheets of foil 8 by 5, waxed bank post paper between.

*Primary Tube.*—Ebonite, $\frac{1}{8}$ in. thick.

*Output.*—With 8 volts 4 amps. 3-in. spark with hammer break; 4 to 5 ins. with the mercury break.

Of the two photographs next following (Figs. 32 and 33) it may be stated that they are both practically rebuilt coils—*i.e.*, no new wire in them, and the sections for the most part simply transferred from old coils, after inspection.



Fig. 32 is built up of single silk- and single cotton-covered wire—*i.e.*, a section of the former is paired with one of the latter and the complete specification is as follows:—

*Core.*—12 ins. by $1\frac{1}{4}$; 22 gauge soft iron wire; re-annealed.

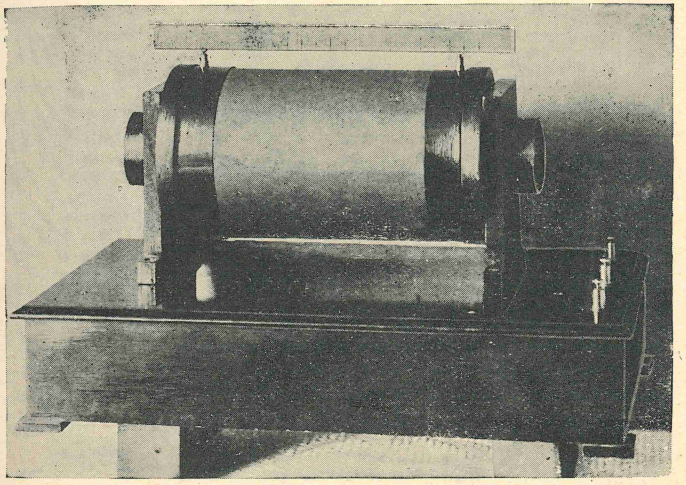


Fig. 32.—An 8-in. Spark Coil.

*Primary.*—Two layers of No. 14 B.W.G. S.S.C., 260 turns.

*Insulating Tube of Ebonite.*—$\frac{1}{4}$ in. thick, 15 ins. long, $2\frac{1}{4}$ ins. diameter; inside $1\frac{3}{4}$ ins. Short sleeves of ebonite on the ends, 4 ins. by $2\frac{1}{2}$ ins. ($\frac{1}{8}$ in. thick).

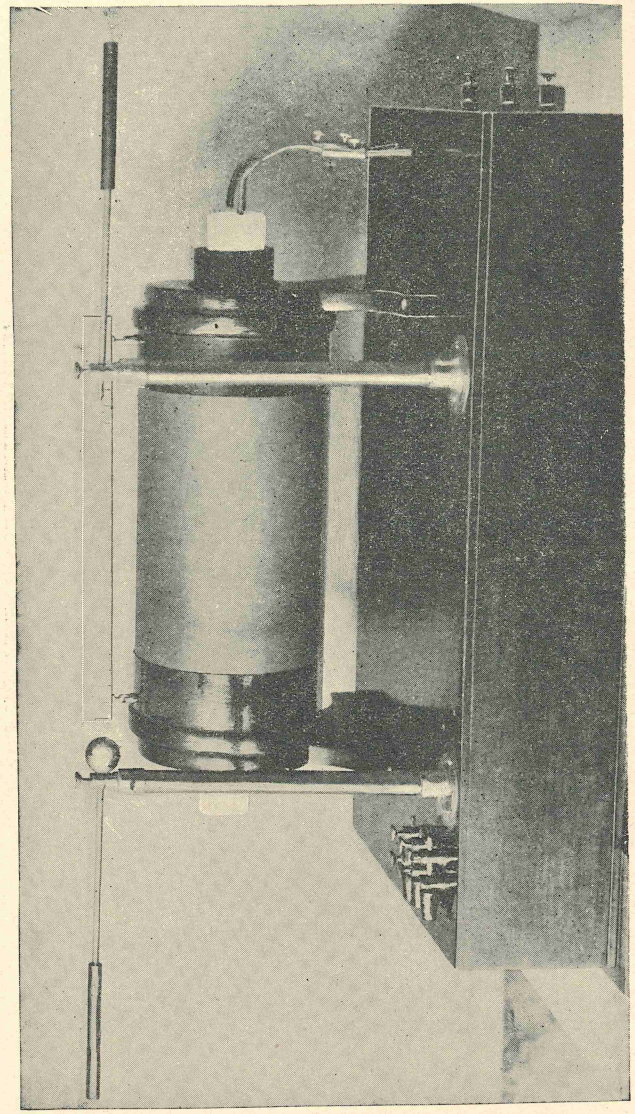


FIG. 33.—AN INDUCTION COIL TO GIVE 11-IN. SPARK.



*Secondary.*—Thirty-six double sections, forming a bobbin $8\frac{1}{2}$ by $5\frac{1}{2}$ ins. Wooden cheeks, $\frac{1}{2}$ in. thick; and ebonite bobbin ends $\frac{5}{8}$ in. thick, 6 ins. diameter; turns of wire on secondary, 35,000 (approximately); distance between secondary terminals, 9 ins.; net weight of secondary wire, 6 lbs. 4 ozs.

*With 8 to 10 volts 8 amps. sparks across the terminals are produced. With 8 volts 8 or 9 amps., fat continuous 8-in. sparks are easily obtained.*

Fig 33, the larger of the two, is built entirely of single cotton-covered wire—*i.e.*, the secondary.

*Core.*—15 ins. by $1\frac{1}{8}$ ins.; primary two layers of No. 14 B.W.G. silk-covered wire; 350 turns.

*Ebonite Tube.*—18 ins. by $2\frac{1}{4}$ ins.; $\frac{1}{4}$ in. thick.

Length of secondary winding, $10\frac{1}{2}$ ins.—viz., forty-four double sections; 25,000 turns of wire (approximately); wooden cheeks of hardwood $\frac{1}{2}$ in. thick; and ebonite bobbin ends $\frac{5}{8}$ in. thick, 6 ins. diameter; distance between secondary terminals, 11 ins.; net weight of wire, 7 lbs. 4 ozs

Sparks 9 ins. easily with 8 volts 8 or 9 amps., and with another cell or two, say, 12 volts 9 amps., will spark across the terminals, which are, as stated, 11 ins. apart.

In no part of this coil is the secondary wire *less* than $\frac{1}{2}$ in. from the primary, and at the ends it is $\frac{7}{8}$ in. at least.

The core with its primary winding—one of the three described in an early article—is an easy fit, and requires a layer of thick waxed blotting-paper

to support it neatly within the tube. There is probably a full inch of substantial insulation at the ends.

Since the above was written the coil (Fig. 32) has again been altered. Two or three double sections were removed from each end—about 1 lb. in weight—and 1 lb. of No. 35 S.C.C. wire wound in double sections put on each end. The object of this was to ascertain what, if any, difference would be observed in the thickness of the spark—in this case hardly noticeable. A new ebonite tube, 3 ins longer than the old one, was put in at the same time—a distinct improvement. The secondary is now practically the length of Fig. 33, and gives as nearly as possible the same results. The weight of wire upon this coil is under $7\frac{1}{2}$ lbs. Sparks are easily obtained between the terminals, and with the *dischargers* as far apart as possible, continuous and thick sparks between ball and point (9 ins.) are obtained with 10 volts 9 amps. The coil has also been raised to $2\frac{1}{2}$ ins. above the base.

## CHAPTER XV.

### Radiographic Work.

As already alluded to in the chapter on "Breaks" certain interrupters are better adapted than others for *X*-ray work. For screen illumination the interruptions should follow one another very rapidly so that we may get even fluorescence—*i.e.*, the greatest freedom from flicker. If the break is not working at its best the fact is shown at once on the screen by a flickering which is annoying, if not altogether fatal to a proper examination of the subject. The hammer break of one of these mentioned answers well for screen work, but it must be in good working order, the platinum points making good contact. With this class of break the interruptions are rapid and regular, though of course they are outclassed altogether by the Wehnelt, the Mackenzie-Davidson and the Turbine breaks. A motor mercury break is also satisfactory, but the simpler form of mercury break is better suited to photography, *e.g.*, Fig. 12.

On the matter of *X*-ray tubes, these are supplied to suit the spark length of coil to be used; for the coils described a 6-in. tube is used. The tubes are

mostly "soft" at first, and will fluoresce with less than 6-in. spark (3 ins., or even 2) and their penetrative power increases considerably the longer they are in use—*i.e.*, they become harder—the vacuum is higher and more than a 6-in. spark will be required. There is undoubtedly considerable difference in tubes. The Watson penetrator tube has distinctive features, and for photographic purposes is an acquisition. One small tube which the writer possesses is of no use, practically, with the spark coil; but with a Tesla coil it not only illumines the screen equal almost to the extent of a 6-in. coil, but acquires great penetrative power: the focus is of the diffused character, but the penetration more than compensates for this. There may be something in the fact that the tube, though small, is of more than ordinary length, and between the terminals measures 9 ins. Detailed allusion to the Tesla coil is made further on.

Some tubes, particularly when "soft," also display a quality for differentiation—that is to say, the negative will be full of half-tones, the bones perfectly distinct, but the flesh distinguishable and even some of the organs. A negative of the kind can hardly be termed "under exposed," so that the phenomenon must be explained in some other way. With the very same tube on occasion the writer has found nothing visible at all on the screen, the bones of the hand, for instance, being as transparent to the rays which were passing at the time as thin ebonite.

Smaller tubes can be worked from the large coil, but a rheostat must first be adjusted in circuit so



that the spark is reduced to the length suitable for the tube; when these get hard and require a longer spark we are able to supply by readjustment of the resistance.

The usual discharging rods should be left *in situ*, to form an "equivalent spark-gap." Supposing that we are using a 4-in. tube, the latter will be connected to the secondary terminals direct; or by attachment to a ring on the discharger pillar; a wire is, of course, carried from the opposite ring to the secondary. The discharger rods may then be placed 2 or 3 ins. apart. The discharge will always take the path of least resistance, and if sparks pass between the points of the dischargers we can increase the distance between them until the discharge prefers to pass through the tube. If we get the characteristic fluorescence with the points 4 ins. apart, we say that the equivalent spark-gap of the tube is 4 ins., and for a small tube the probability is that it will prove to be fairly hard. A tube would be very soft if it fluoresced with an equivalent spark-gap of 1 or 2 ins. Tubes may be made harder if the current is discharged through them in the wrong direction, and a hard tube may be rendered softer by careful and even warming with a spirit flame.

Fluorescent screens may be of barium platinocyanide or of calcium tungstate. The universal opinion is in favour of the former, though the difference is not so great as some radiographers suggest. One of the latter fluorescent salt made by the writer

gave great satisfaction. When the tube and coil were at their best, there was very little to choose between them ; but if the contrary, then the barium salt easily took the palm. The outfit for *X*-ray work should include one of each, the barium screen for the fluoroscope or visual work, and the tungstate screen for photography. It has been found that this screen greatly assists in shortening the exposure when taking a radiograph ; for this purpose the screen should be used with its sensitive side in contact with the film of the photographic plate.

The tungstate screen will be used not only to assist and reduce the exposure, but if backed up with a piece of black paper and put into a frame may be found serviceable in other ways. Held near to the tube and within the influence of the rays, its faults, if home-made, will become apparent—most probably unevenness of surface—and may possibly be remedied by additional sprinkling of the fluorescent salt where required, but too liberal sprinkling is a mistake.

There is little doubt that a rapid plate is best for photography with *X*-rays. The "Imperial Extra Rapid" will for ordinary work do excellently. No doubt any other with the same relative sensitiveness will answer as well. Considerations of price only prevent one from getting the very quickest plates for all purposes, and of course cases occur in which it will be imperative not to prolong the exposure ; therefore the question may be put, whether in all



cases the quickest will not be the cheapest in the end.

Films are undoubtedly useful in some cases, for the reason that in a suitable envelope or covering they may be bent or curved round a limb or otherwise placed in closer contact with the part. As a rule, also, films are very sensitive, and they are certainly much better, physically, than they used to be. A film, however, will always retain the characteristics of a film, and these are for the most part rather of the negative variety ; a developed film is rarely so clean and uniform as its compatriot on glass, and scratches and markings appear to be indigenous to films. These little faults, however, do not interfere in any way with their value for *X*-ray work. This point is mentioned because films are, as we have said, at times a decided acquisition. On the other hand a plea is entered here on behalf of a higher technical standard for radiographic photography generally. It is a fact that some men with access to apparatus of the best and an apparently blank cheque with regard to material continue to turn out extremely mediocre work. One does not require the whole range of photographic processes for the work, but considering the value of all radiographic records in surgery the operator should be a fairly expert photographer.

In the matter of exposures we are helped very much if we can see the effect first on the screen. The range of exposures varies considerably, and the following short table may be of use :—

*Coil giving 8-in. Spark.*

| | | |
|---|---|---|
| Hand | .. .. | Half to one minute. |
| Elbow | .. .. | Two to three minutes. |
| Knee | .. .. | Two to four minutes. |
| Thorax | .. .. | Five to ten minutes. |
| Pelvis | .. .. | Five to ten minutes. |
| Foot | .. .. | One to two minutes. |
| Ankle | .. .. | Two to four minutes. |

There is in this class of work very small latitude in exposure—that is to say, the correct exposure being thirty seconds, an under-exposure, say equal to twenty seconds, cannot be by alteration of the developer brought up to the level of the former. On the other hand, an exposure of forty or even fifty seconds need not mean a failure.

A standard developer to which one is accustomed is the best to use. The Paget Prize Plate Company's developer is one which the writer has used for twenty years or so.

*Stock Solutions.*

| | | | |
|---|---|---|---|
| P. | Pyrogallic acid .. .. .. | 1 | oz. |
| | Citric acid .. .. .. | 60 | grs. |
| | Soda sulphite (pure) .. .. .. | $2\frac{1}{2}$ | ozs. |
| | Distilled water .. .. .. | 20 | ozs. |
| A. | Liquid ammonia ·880 .. .. | 1 | oz. |
| | Ammonia bromide .. .. .. | 80 | grs. |
| | Distilled water .. .. .. | 20 | ozs. |

For normal exposures the above are used in equal quantities of each, diluted with water. One part



of each and ten parts of water—*i.e.*, twelve parts in all of developer—make a normal solution with which we may get full detail and correct density. Such a developer as this may be readily modified. The less water the more vigorous will be the resulting negative ; but too little water involves danger of fog or a general reduction of the light-affected image. If too much water be used, then the image is thinner and flatter. Supposing an exposure to have been made, the exposed plate will, in the dark-room or by ruby light, be placed in a dish and a sufficiency of the developer of normal strength—*i.e.*, P, 1 part ; A, 1 part ; water, 10 parts, poured over it. If properly or correctly exposed the image will appear and attain to full, or at any rate satisfactory, density in about five minutes ; but if the detail appears very tardily, the appearance will indicate that something is on the film but wants accelerating ; now pour off the developer and wash the partially developed plate in fresh water, return to the dish, which must also be clean, and pour over the plate a little of the " A " solution alone diluted with water (one part to nine or ten). Under the influence of this " accelerator " (which is the term usually given to the alkaline portion of a developer) the image will develop slowly but surely, though the effect is not so certain as with plates exposed to actinic light. The " A " solution may be, if necessary, poured off and a fresh supply poured on (owing to evaporation of the ammonia) ; but, arrived at the limit when apparently no more can be got out of it,

the accelerator is poured off finally and the normal solution again used. This will at once give us fair printing density. When the exposure has been knowingly and necessarily shortened, the best development is in a solution very much diluted (using distilled or boiled water). Stand development, as it is called, is usually carried out in a grooved tank fitted with a lid and the whole arrangement light proof. The developer is made to formula below :—

| | |
|---|---|
| Glycin | 40 grs. |
| Sodium sulphite | 200 grs. |
| Potassium carbonate | 200 grs. |
| Potassium bromide | 1 gr. |
| Water | 40 ozs. |

The plate is put into the tank and the solution poured in sufficient to completely cover it—the lid put on and the plate allowed to remain several hours. Whatever detail is impressed on the sensitive plate will be brought out by this method, and density may be imparted to the image by a short immersion in the same developer of normal strength. An acid fixing bath should be used, *e.g.*—

| | |
|---|---|
| Soda hyposulphite | 4 ozs. |
| Water | 20 ozs. |
| Potass. meta bisulphite | 1 oz. |

The negatives obtained will often show plenty of detail, but may still be " thin "—*i.e.*, wanting a little in density. The brand of paper termed " P.O.P." suits such negatives very well, and pleasant tones can be got with it even when not fully printed out. But intensification with the usual mercury bath



sometimes makes a very decided improvement. The well washed negative is immersed in—

| | |
|---|---|
| Mercury bichloride | 1 oz. |
| Water | 20 ozs. |

The salt, which is extremely poisonous, must be dissolved in hot water and the solution is ready for use when cold, and may be used many times before it is exhausted. Care should be taken to label it " Poison," and to store it in a safe place. The plate becomes bleached in this bath, a compound of silver and mercurous chloride being formed. After more washing—several changes in addition to half-an-hour or so under running water—the film is treated to a bath of ammonia—

| | |
|---|---|
| Sol. ammonia, ·880 | 1 oz. |
| Water | 20 ozs. |

and is at once blackened in the parts affected by the light, very considerable density being given —in some cases—to the image. This makes the negative a much better printer.

It may be mentioned that Edward's " Cathodal " plates are very sensitive to the rays, being coated (so it is said) with a fluorescent chemical which acts in the same way as, or takes the place of, the tungstate screen. These plates are the same price as the ordinary rapid commercial dry plate.

The tungstate screen used as described undoubtedly shortens the exposure very considerably, about one-fourth only of the usual time being necessary ; but unless a really well-made screen—*i.e.*, very evenly and thinly coated—is used, the results will not be

very good pictorially, coarseness of grain and unevenness will inevitably show, and somewhat obscure the

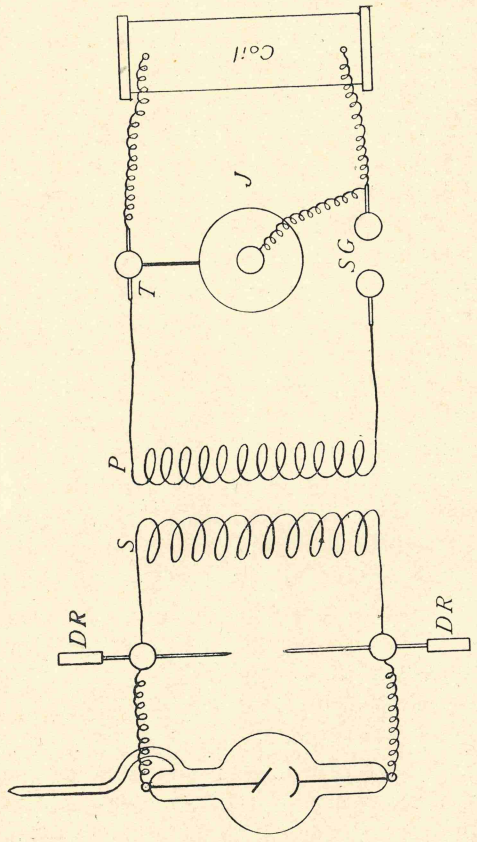



FIG. 34.—DIAGRAM OF CONNECTIONS FOR RADIOGRAPHIC WORK.

picture, although the latter, even with these faults, may be of some use surgically.



Much difference of opinion exists as to the value of the Tesla transformer for working *X*-ray tubes. The writer can speak with only limited authority on the matter, as his experience is confined to a small apparatus which he made for his own use in 1897. The coil—fully described in THE MODEL ENGINEER AND ELECTRICIAN for May 28th, 1903—consists of a primary composed of No. 22 G.P. covered copper wire, one layer upon a cylinder or rod, glass or ebonite, 6 ins. long by 1 in. diameter; and a secondary, one layer of No. 36 double silk-covered wire (about 360 turns) upon a glass cylinder of 2 ins. diameter (an Argand or incandescent chimney about 6 ins. long will serve).

The next figure (34) shows the disposition of the parts and the arrangements for working.

For a Tesla coil of this size a quart Leyden jar suffices, and it may be worked from an induction coil giving a good 2-in. spark.

The writer uses a 3-in. *X*-ray tube of Jackson pattern (shown in the figure). The tube fluoresces finely with the high frequency oscillation produced. The screen is illuminated very evenly, and the penetrative power of the tube (in this case) very much increased. The photograph reproduced on page 66 of January 19th, 1905, issue of THE MODEL ENGINEER, is one of many taken with it, and it will be seen that although the results are not quite so clearly defined as with good tubes used connected direct to a coil, the diffusion of focus is not unpleasing.

## CHAPTER XVI.

### The Repair of Sectionally Wound Spark Coils.

The repair of a coil which suddenly fails to give the correct or standard length of spark is not the serious operation it has been in years by no means distant, provided, of course, that it is wound in sections.

Supposing the spark length be reduced considerably—from 6 ins., say, to 1 or 2 ins.—it will be safe to conclude if break, battery, and condenser are in good working order, that there is a decided breakdown in the insulation ; the question will be, where ?

Condensers can best be tested when the coil is or can be fitted with a hammer break. We mean that if the condenser is one made as suggested where 10, 20, 30 and so on to 70 sheets of foil may be utilised, the variations in spark length obtained are more noticeable with an " Apps " break or a " Vril " than with the mercury break. A spare condenser is desirable, if not absolutely necessary ; it can be cheaply made, and, neatly covered and cased in with thin mahogany, is an ornamental and useful accessory.

But supposing, again, that the 6-in. spark is reduced to 3 or 4 ins. ; that with the same battery power, as tested by volt and ampere meters, the



break being in its normal condition no more than 3 or 4 ins. are available, then it is probable that the insulation has broken down, in all probability *at the ends*—one or both—of the secondary, between the first few sections and the primary.

In the first place, and before attempting to dismount the coil, the ebonite cover should be removed, the wax covering being exposed fully to view. Then the coil should be worked in the dark, and the outside of secondary closely inspected : there may be leakage from one section to another in the outside turns if by any mischance any of them have been filled too full of wire. This leakage would be demonstrated by flashes of light in and through the wax, and clearly visible. This must not be confused with a faint brush discharge, due to air bubbles in wax next turns of wire. Any such places should be at once marked, the coil disconnected from the battery, and the place or places investigated.

A clean soldering iron made quite hot will very quickly run all the wax off at the particular spot and reveal the mischief, which may be the result of two wires adjoining having become bared of covering, or possibly a leak from one section to another. Such a fault as this indicates at once the measures to be adopted to remedy the same ; the wax should be run off all round by careful and painstaking use of the hot iron until the section, and one or two adjoining, are laid open and the wire exposed to view ; it is a by no means difficult matter to take

off several turns of the wire from the faulty sections, but the coil would have to be dismounted, and mounted afresh between a couple of strong wooden standards.

This stand, if made so that when the coil is placed in the supports there is room for a shallow tin tray to stand beneath it, as already described, enables us to turn the bobbin round and, practically, baste off the wax at any point or section. If wire is to be taken off—and if there has been sparking there will be clear evidence of the same in the shape of blackened turns of wire—we must clear a space wide enough to allow of a careful search for the joint or joints between the section and its neighbour on either side. By keeping the place *uniformly hot* we can easily do this. The joint should be found, separated, a turn or two of wire taken off, and a temporary joint made at once. It is most important not to lose sight and touch of the joint. But suppose one section only is at fault—say, for instance, the one marked " 1st " (Fig. 28)—it will be seen from that drawing that it will be an easy matter to take off several turns or layers, and to then make a fresh joint ; and similarly on the other side, if that requires treatment also.

Any fault such as above outlined will make a decided difference to the output of the coil, and if left untouched would certainly get worse, and possibly involve other sections.

It may be here mentioned, though the careful worker will have noticed it possibly for himself when covering with wax the secondary windings



in the manner described on page 90, that nothing succeeds better for getting the wax *off the bobbin*—even the whole of it—than pouring hot wax *over it.* For instance, if the tin casing were placed round the bobbin and heat applied it would be a long and tedious business to melt the jacket of wax ; but if several small holes are drilled in the bottom of this cover—if, moreover, the cover be fixed so that an interval of $\frac{1}{4}$ in. all round is made between it and the wax, easily achieved by packing (with long narrow strips of cardboard or leather) the two wood discs, then on pouring in any hot wax through the slit at the top—catching it in the tray beneath—we can easily and quickly run off all the wax covering the sections, and they will be left entirely bare. It would, indeed, be a wise measure to adopt this plan and then to thoroughly and systematically examine the outside turns of every section.

At the same time it is well to trace all the outside connexion, and to be certain that the wire runs in one direction throughout.

The outside of coil may demonstrate the symptoms described, and the defect being remedied, the further testing of the work—by connecting with condenser, break, and battery—will probably show that a cure has been effected. If, however, the output is still below the standard, it is likely that there is a leak between *the first turns* of a section and the primary. One of the advantages of a movable core is that this fault can soon be discovered, as by looking in at the ends of the tube while the coil is being

worked—it can be clearly *seen* if there is any sparking on to the primary, and it will no doubt be *heard* before it is seen. We learn by failures, and a coil built by the writer broke down badly in this way: the core, which was an easy fit, was withdrawn, and a turn of thin brown paper put round it; again inserted and the coil operated: smoke issued first from one, and then from both the ends. Removing the core again, it was found that at two places the paper had been singed, and looking through the tube—by holding the entire coil up to a good light—smoked patches were easily seen, and in the centre of each a hole in the ebonite tube. Repairs were effected, and the coil was very efficiently restored by working as follows:—

The coil, removed of course from the condenser box, must be—*partially*, at any rate—rebuilt. This may sound a serious business, but need not be made so. Firstly, the bobbin should be mounted in the stand above referred to, and slowly turned in front of a hot fire, all the outside covering of wax run off. Secondly, having a tripod stand (it must be a foot high) and a Bunsen burner ready for use, the bobbin is placed end up on the tripod and a small jet of gas allowed to send up heat through the ebonite tube. Very soon we are able to warm the tube throughout—assisted by reversing the bobbin—and before long make it hot enough to melt the wax surrounding it; the result is that the tube may be drawn out intact.

Having arrived at this stage we may see by looking



through the cylindrical space where the fault lies. In the case referred to, having measured the distances, we were able to ascertain at the first glance, and there were two places, visual proof being given by black patches, denoting where the faulty sections were to be found.

It must be remarked here that we are rather at the mercy of manufacturers in the matter of efficient covering of wire and uniform density of the ebonite. If the ebonite tube be defective—if, moreover, it happens that two small bare patches in the wire, possibly only a fraction of an inch, come together—then it is a matter of time only for the coil to break down.

Now, the bobbin should be replaced on the tripod and the Bunsen again brought into requisition for the purpose of running as much wax as possible out of the *inner* turns. As a fact, in working with heat suitably applied inside and out, it is possible, with the minimum of damage and loss, to separate with a knife every double section; but this is rarely necessary. Having located the fault, we work down to the section or sections involved, but bearing in mind that all have to be replaced upon a new tube, it is a good plan to remove them all in blocks of, say, four *double* sections each, but not much more than 1 in. in total thickness.

To come to the faulty sections. These may be very easily treated by adopting the method here suggested. No re-winding is necessary. Have ready several blotting-paper discs of suitable size, and

make the double sections warm enough to enable one to—having cut the inner wire which joins them—easily separate the two. They should be at once placed between new insulating discs; then, having cooled, pull out enough of the inner turns to remove entirely all the implicated wire; leave an inch or two for joining, and run a little hot wax into the first few turns to hold these tightly.

Now pair the two sections again exactly as they were, so that the two short lengths of wire are opposite one another. Some means should be adopted to secure the two sections one to the other, *e.g.*, by warming the inner and outer edges of the blotting-paper insulating discs, and, this done, the double section may be held firmly enough, but without undue pressure, in a vice the jaws of which have been covered with pieces of thin wood. This is not absolutely necessary; but it is an advantage to have the double section firmly held in a vertical position, so that both the operator's hands are free. The two separating discs (or double discs) of blotting-paper should, of course, as previously described, have their central aperture smaller by at least $\frac{1}{8}$ in. all round than the annulus of wire. The new joint between the two sections is now to be made on the edge of this; the two opposing wire ends are carefully bared of covering to this point, twisted together soldered, cut down, the joint insulated with a small piece of waxed silk, and either tucked in or left resting on the edge; the latter is perfectly safe; the joint is bent down to rest on, and partly in, the



soft paper, the silk patch is placed over it—like a saddle—and if a needle and thread are at hand very safely tied there.

Thus we are able, as will be seen by the thoughtful reader, to repair the coil by inserting a new tube (or to rebuild upon one which may be thicker in section), with some pains certainly, but very trifling loss. It is very rarely necessary to re-wind the sections, as, even if too small or tight a fit for a new tube, it is easier, and probably cheaper, to simply remove a few of the inner turns. Care must be taken to ensure that the repaired sections are wound in the same direction as the remainder, and all connected once more, so that the wire runs in exactly the same direction throughout, and all—including those which may have been removed in blocks of four or more—should be properly tested with the galvanometer for continuity before starting to rebuild.

While the secondary bobbin is quite hot, as it will be if the treatment above has been followed, it will not be a difficult matter to remove the ebonite ends, and, after mounting the coil upon the upright stand (the tripod), to thoroughly warm up and treat with fresh wax each of the ends, endeavouring at the same time to get as much pressure as possible exerted. It is possible with the bobbins thoroughly warmed up to reduce the length, by end pressure, to the extent of nearly one in twenty.

## CHAPTER XVII.

### Electrographic Work.

Photographic records of electric discharges are extremely interesting, from their variety and beauty of outline; they are, also, by no means difficult to produce, neither is a spark coil of large size necessary. As a fact, the large coil produces, relatively, no better pictures than the small, while the cost in dry plates will perhaps be an important matter.

Figs. 35 and 36 are typical negative and positive results respectively of the secondary discharge of any good coil. They are taken as follows:—

Upon a piece of tinfoil nearly the size of dry plate used, place the latter—sensitive side up—attach a wire from one secondary terminal in contact with the foil, and another wire *terminating in a brass ball*, on to the centre of the dry plate (all this, of course, in a safe light, or the plate may be in a light tight envelope), discharge the coil, develop the plate, and the result is as Fig. 35 (negative) or Fig. 36 (positive). For the next plate, reverse the connecting wires. In place of a ball a point may be used and the figure then radiates from a definite point: by using a ball the figure is broken up—*i.e.*, there is no heavy discharge at one part and better photographs result



technically. The shape of the metal backing has some bearing on the direction taken by the spark, and, of course, the beauty of the figure depends somewhat upon this consideration.

Very similar results, again, are obtainable from the terminals of the small Tesla coil. The difference here is that the lines are much finer, *i.e.*, very furry, but there are always sufficient indications of the negative and positive figures. Numerous similar photographs were reproduced in the pages of The Model Engineer dated May 5th and 12th, 1904.

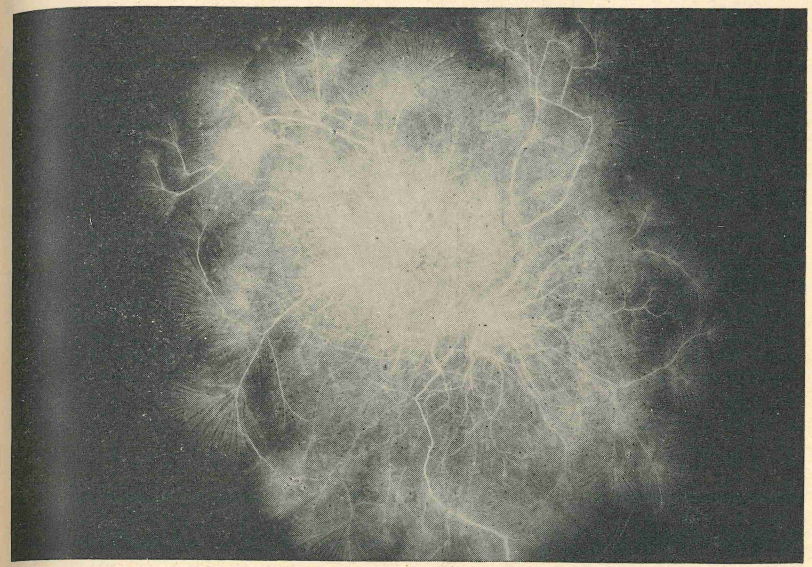


Fig. 35.—Negative Spark.

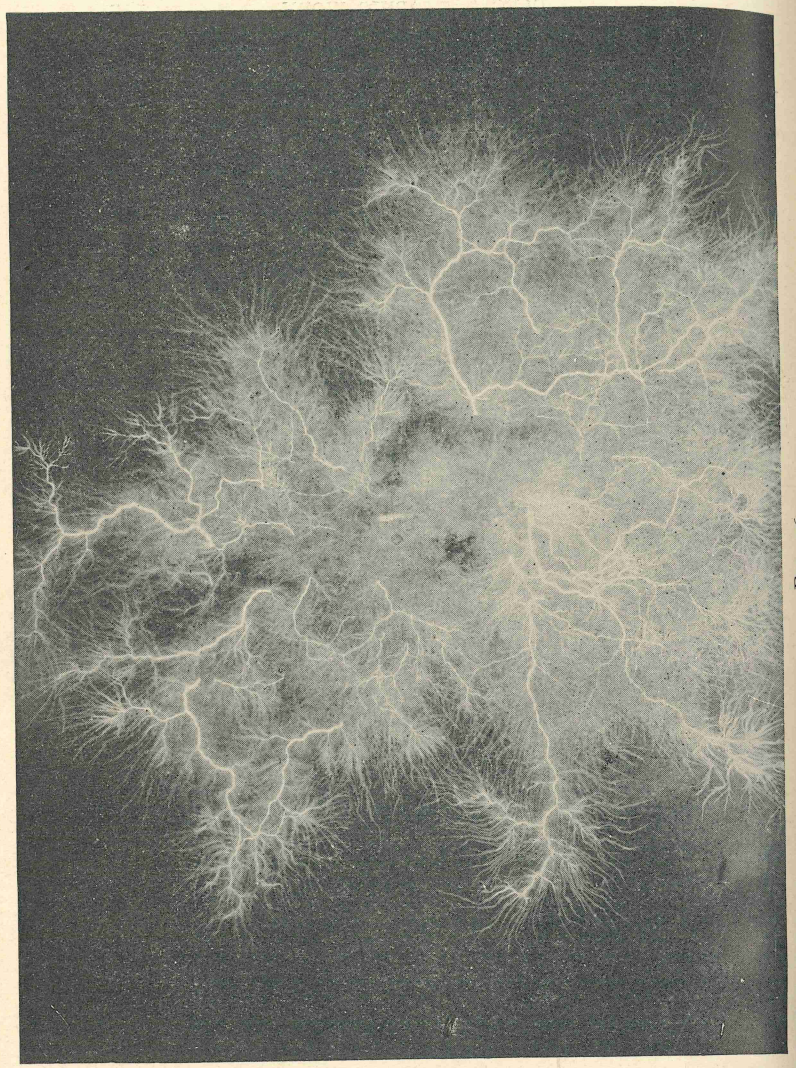


FIG. 36.


# LIST OF
# Technical Books

SUPPLIED BY

## Percival Marshall & Co.,

66, FARRINGDON STREET, LONDON, E.C.

Any Technical Book not in this List can be supplied to order. Inquiries are invited, and will be answered by post free of charge. Foreign and Colonial customers please note that the postages given, unless stated, are for Great Britain, and extra money should be sent to cover the higher postage for Colonies and Foreign Countries.

## MECHANICAL ENGINEERING.

### Gas and Oil Engines, and Gas Fitting.

**Design and Construction of Oil Engines.** By A. H. Goldingham. Deals with erecting, testing, installing, running and repairing. Third Edition. 260 pages. 112 Illustrations. Postage 6d. ... ... ... 10s. 6d.

**A Practical Treatise on Modern Gas and Oil Engines.** By Fred. Grover, A.M.Inst.C.E. Fifth Edition. Illustrated. With 365 pages. Postage 4d. ... ... ... ... ... ... ... 5s. 0d.

**Acetylene: The Principles of its Generation and Use.** By F. H. Leeds, F.I.C., F.C.S., and W. J. Atkinson Butterfield, M.A., F.I.C., F.C.S. With Diagrams and Illustrations. Postage 5d. ... ... ... 3s. 6d.

**The Gas Engine Manual.** By W. A. Tookey. A well illustrated and practical Handbook for Gas Engine Users. Postage 4d. ... ... 3s. 6d.

**Gas and Petroleum Engines.** Adapted from the French of H. De Graffigny, by A. G. Elliott, B.Sc. A Useful and Elementary Treatise for Non-Technical Readers. With 52 Illustrations. Postage 3d. ... ... 2s. 6d.

**Practical Gas Fitting.** By Paul N. Hasluck. With 120 illustrations, 166 Pages. Cloth. Crown 8vo. Postage 3d. ... ... 2s. 0d.

**Gas Engines: Their Advantages, Action, and Application.** By W. A. Tookey. Hints to Purchasers, Erectors, and Attendants. Postage 2d. 1s. 0d.

**Oil Engines: Their Selection, Erection and Correction.** By W. A. Tookey. Many types of Engines described shortly. Postage 2d. 1s. 0d.

**Gas Producers for Power Purposes.** By W. A. Tookey. For the use o Purchasers, Erectors and Attendants. Postage 2½d. ... ... 1s. 0d

**How to Manage a Suction Gas Producer.** By W. A. Tookey. Illustrated Postage 2d. ... ... ... ... ... ... ... 1s. 0d

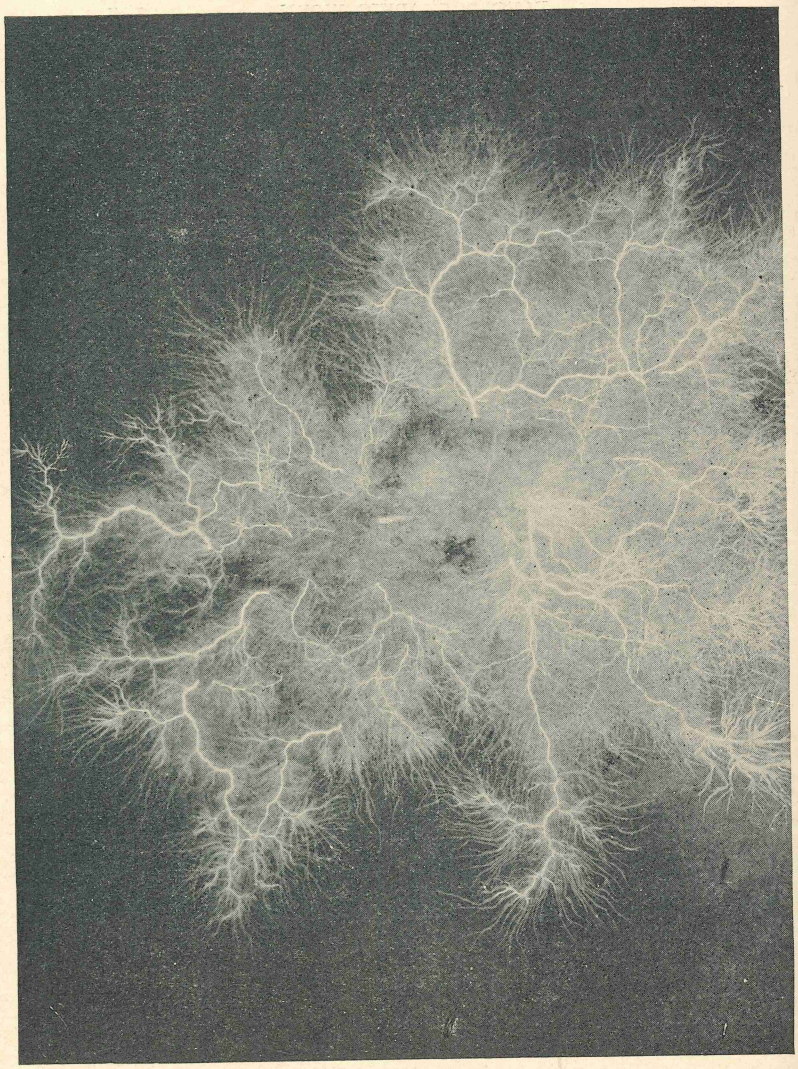


FIG. 36.


LIST

Technical

SUPPLIED

Percival Mars

66, FARRINGDON STRE

Any Technical Book not in t
order. Inquiries are invited, and
free of charge. Foreign and Colo
that the postages given, unless st
and extra money should be sent t
for Colonies and Foreign Countri

MECHANICAL EN

Gas and Oil Engines, and

**Design and Construction of Oil Engines** with erecting, testing, installing, runni 260 pages. 112 Illustrations. Postage 6d

**A Practical Treatise on Modern Gas an** A.M.Inst.C.E. Fifth Edition. Illust tage 4d. ... ... ... ...

**Acetylene: The Principles of its Gener** F.I.C., F.C.S., and W. J. Atkinson Butt Diagrams and Illustrations. Postage 5d.

**The Gas Engine Manual.** By W. A. Tooke Handbook for Gas Engine Users. Postag

**Gas and Petroleum Engines.** Adapted fr by A. G. Elliott, B.Sc. A Useful and Elen Readers. With 52 Illustrations. Postage

**Practical Gas Fitting.** By Paul N. Has Pages. Cloth. Crown 8vo. Postage 3d.

**Gas Engines: Their Advantages, Actio** Tookey. Hints to Purchasers, Erectors, an

**Oil Engines: Their Selection, Erection** Tookey. Many types of Engines describe

**Gas Producers for Power Purposes.** By Purchasers, Erectors and Attendants. Po

**How to Manage a Suction Gas Producer** Postage 2d. ... ... ... ...

**Gas and Oil Engines.** Simply explained. By W. C. Runciman. An Elementary Instruction Book for Amateurs and Engine Attendants. Fully Illustrated. Postage 1d. ... ... ... ... ... ... 6d.

## General Engineering.

**A Text Book of Mechanical Engineering.** By Wilfrid J. Lineham, M.Inst.C.E., M.I.Mech.E., M.I.E.E. Contains 1,000 pages, with 920 Illustrations and 19 Folding Plates. Postage 6d. ... ... ... 12s. 6d.

**Engineer's Sketchbook of Mechanical Movements, Devices, Appliances, etc.** For use in the Design and Construction of Machinery. By T. W. Barber, M.Inst.C.E. Fifth Edition. 3000 Illustrations. Postage 5d. 10s. 6d.

**The Repair and Maintenance of Machinery.** By T. W. Barber. With 417 Illustrations. 8vo. Postage 5d. ... ... ... ... 10s. 6d.

**Mechanical Refrigeration.** By Hal Williams, A.M.I.E., A.M.I.E.E. With 115 Illustrations. Crown 8vo. Postage 4d. ... ... ... ... 10s. 6d.

**Mechanical Movements, Powers, Devices, and Appliances.** By Gardener D. Hiscox. For the use of Inventors, Mechanics, Engineers, Draughtsmen, and all others interested in any way in Mechanics. Illustrated by 1,642 Engravings. 402 pages. 8vo. Cloth. Postage 5d. ... ... 8s. 6d.

**Applied Mechanics and Mechanical Engineering.** In Five Volumes. Large Crown 8vo. By Professor Andrew Jamieson.
Vol. I.—Applied Mechanics. Eighth Edition. Postage 4d. ... 6s. 0d.
Vol. II.—Strength of Materials. Eighth Edition. Postage 4d. 5s. 0d.
Vol. III.—Theory of Structures. Eighth Edition. Postage 4d. 5s. 0d.
Vol. IV.—Hydraulics. Eighth Edition. Postage 4d. ... ... 5s. 0d.
Vol. V.—Theory of Machines. Seventh Edition. Postage 5d. 7s. 6d.

**Toothed Gearing.** By J. Horner, A.M.I.M.E. A Practical Handbook for Offices and Workshops. With 184 Illustrations. Crown 8vo. Cloth. Postage 4d. ... ... ... ... ... ... 6s. 0d.

**The Chemistry of Materials of Engineering.** By A. Humboldt Sexton. Crown 8vo. Postage 4d. ... ... ... ... ... 5s. 0d.

**Practical Notes on the Construction of Cranes and Lifting Machinery.** By Edward C. R. Marks, A.M.I.C.E., M.I.M.E. New and Enlarged Edition. Crown 8vo. Postage 4d. ... ... ... ... ... 3s. 6d.

**Elementary Manual of Applied Mechanics.** By Prof. Jamieson. Specially arranged for First Year Students. Fifth Edition. With Illustrations and Examination Papers. Crown 8vo. Postage 4d. ... ... 3s. 6d.

**Engineering Workshop Practice.** By Charles C. Allen. This book is intended as a guide for Students and Engineering Workmen generally. Illustrated. Postage 4d. ... ... ... ... ... 3s. 6d.

**The Strength of Materials and Structures.** By Sir J. Anderson, C.E., LL.D., F.R.S.E. Showing the strength of materials as depending on their quality and as ascertained by testing apparatus. With 66 Illustrations. Fcp. 8vo. Postage 3d. ... ... ... ... ... ... ... 3s. 6d.

**Mechanical Engineering Materials.** By Edward C. R. Marks, A.M.I.C.E. M.I.M.E. Postage 3d. ... ... ... ... ... 2s 6d.

**The Engineering of Ordnance.** By A. Trevor Dawson, Lieut. R.N. Gustave Canet Lecture. 68 Illustrations. Postage 3d. ... ... 2s. 6d.

## Locomotives and Railways.

**Modern Locomotive Practice.** By C. E. Wolff, B.Sc., A.M.I.M.E. A treatise on the Design of Steam Locomotives. With 150 Illustrations and 8 folding Plates. Postage 4d. ... ... ... ... ... 10s. 6d.

**British Locomotives.** Their History, Construction, and Modern Development. By C. J. Bowen Cooke. With 150 illustrations. Third Edition. Thoroughly revised. Crown 8vo. Postage 4d. ... ... ... ... 7s. 6d.

**Locomotives of 1906.** By C. S. Lake. A Supplement to The World's Locomotives. Postage 3d. ... ... ... ... ... 1s. 0d.



**Locomotives of 1907.** By C. S. Lake. A Supplement to The World's Locomotives. Postage 3d. ... ... ... ... ... 1s. 0d.

**The Locomotive Engine and its Development.** By Clement E. Stretton, C.E. A popular Treatise on the Gradual Improvements made in Railway Engines between 1803 and 1903. Sixth Edition. Revised and Enlarged. With 130 Illustrations. Crown 8vo. Cloth. Postage 4d. ... 4s. 6d.

**Modern British Locomotives.** By A. T. Taylor. 100 Diagrams and principal Dimensions. Postage 3d. ... ... ... ... ... 4s. 6d.

**The Locomotives of the G.N.R.** By George Frederick Bird. A Chronological account of the Locomotive Stock of the G.N.R. from its inception to the present day; every type illustrated and described. Postage 3d. 3s. 6d.

**Locomotives of the L.B. & S.C.R.** A complete history of all the locomotives of the L.B. & S.C.R. from 1839 to the present day. 144 illustrations from Drawings and Photographs, every engine illustrated and described. Postage 3d. ... ... ... ... ... ... 3s. 6d.

**Railway Appliances.** By Sir J. Wolfe Barry, K.C.B., F.R.S., etc. A Description of Railway Construction subsequent to the completion of the Earthworks and Structures. With 218 Illustrations. Fcp. 8vo. Postage 3d. 4s. 6d.

**The Locomotive Portfolio.** By F. Moore. Containing 12 beautifully executed Coloured Plates of Modern British Express Locomotives. Postage 4d. 3s. 6d.

**The Locomotive of To-day.** A thoroughly practical Treatise on the British Locomotive; every detail carefully illustrated and described. Post. 3d. 2s. 6d.

**Railway Working and Appliances.** By Edward S. Hadley. Describes the Methods and Mechanisms by which Railways in Great Britain are conducted. Illustrated, Postage 3d. ... ... ... ... ... 1s. 6d.

**The Locomotive Simply Explained.** By C. S. Lake. A First Introduction to the Study of the Locomotive Engine. Postage 1d. ... 6d.

**The Model Railway Handbook.** By W. J. Bassett Lowke. A Guide to the Choice of Model Locomotives and Equipment. Illustrated. Postage 2d. 6d.

## Machine Design and Drawing.

**The Elements of Machine Design.** By W. Cawthorne Unwin, F.R.S.
Part I. General Principles, Fastenings, and Transmissive Machinery. With 345 Diagrams, etc. Postage 4d. ... ... ... 7s. 6d.
Part II. Chiefly on Engine Details. With 259 Illustrations. Postage 4d. ... ... ... ... ... ... ... 6s. 0d.

**Mathematical Drawing Instruments and Materials.** By A. G. Thornton. Describes all Instruments and Materials used in Drawing, Tracing, &c. Postage 4d. ... ... ... ... ... ... ... 1s. 6d.

**Machine Drawing.** By T. Jones, M.I.M.E., and T. G. Jones, M.Sc., Wh.Sc.
Book 1. Thirteenth Edition. Enlarged. General Details of Engines and Machines. 69 Plates (four coloured). Postage 4d. ... 3s. 6d.
Book 2. Machine Tools. Drilling, Planing, Slotting, and Shaping. Enlarged Edition. 48 Plates (four coloured). Postage 4d. ... 3s. 0d.
Book 3. Engine and Pump Details. Third Edition. 44 Plates (four coloured). Postage 4d. ... ... ... ... ... 3s. 0d.
The above three books, handsomely bound in one volume. Post 6d., net 12s. 6d.
Book 4. Electrical Machines and Details. 16 Plates. Postage 2d. 1s. 0d.

**Sketches of Engine and Machine Details.** By Wallace Bentley, M.I.M.E. This book contains over 200 Detail Drawings, fully dimensioned, from the latest practice, and includes drawings from Stationary, Locomotive, and Marine Engines, Boilers, Gas and Oil Engines, Machine Tool, Electric Motors, etc. Fourth Edition, enlarged. Postage 3d. ... ... 2s. 6d.

**Machine Drawing and Sketching for Beginners.** By J. H. Robson, A.M.I.M.E. A useful book for all beginners in Machine Construction and Drawing. Contains 191 pages and over 300 illustrations. Postage 4d. 2s. 6d.

**An Introduction to Machine Drawing and Design.** By David Allan Low. With 153 Illustrations and Diagrams. Crown 8vo. Postage 3d. 2s. 6d.

**Machine Shop Arithmetic.** By Colvin. A Pocket Book containing Solutions to Problems met with by every mechanic. Postage 2d. ... 2s. 6d.

**Engineering Mathematics Simply Explained.** By H. H. Harrison A Textbook for Apprentices, Students and Engineers. Postage 3d. 1s. 6d.

**Engineer Draughtsmen's Work.** By a Practical Draughtsman. Hints to Beginners in Drawing Offices. Second Edition. With 80 Illustrations. Postage 2d. ... ... ... ... ... ... ... 1s. 6d.

**Mechanical Drawing Simply Explained.** An Elementary Handbook on Engineering Draughtsmanship for Students, Apprentices and Amateurs. Fully Illustrated. Postage 1d. ... ... ... ... 6d.

**How to Read a Workshop Drawing.** A useful book for beginners, describing how to understand Drawings. Postage 1d. ... ... 6d.

## Marine Engineering.

**Marine Engineer's Guide for Board of Trade Examinations for Certificates of Competency.** By A. C. Wannan, C.E., and D. Lindsay. Fifth Edition. Revised and further enlarged. In Two Volumes:
Arithmetic. Postage 4d. Abroad 8d.... ... ... ... 6s. 0d.
Elementarys, Verbals and Drawings. Postage 4d. Abroad 8d. 6s. 0d.

**Verbal Notes and Sketches for Marine Engineers.** Contains Notes and Sketches given at the Board of Trade Examination. By J. W. Sothern. Postage 4d.... ... ... ... ... ... ... 7s. 6d.

**Drawing and Designing for Marine Engineers.** By Chas. W. Roberts, M.I.Mar.E. With 27 Illustrations and 21 large Plates. Demy 8vo. Cloth gilt. Postage 4d. ... ... ... ... ... ... 6s. 0d.

**Engine-room Practice.** By John G. Liversidge, A.M.I.C.E., etc. A Handbook for Engineers and Officers in the Royal Navy and Mercantile Marine, including the Management of the Main and Auxiliary Engines on board ship. Third impression, with numerous Illustrations. Lrg. cr. 8vo. Postage 4d. 6s. 0d.

**Elementary Lessons in Steam Machinery, and the Marine Steam Engine.** By J. Langmaid, R.N., and H. Gaisford, R.N. With a Short Description of the Construction of a Battleship. Compiled for the Use of Junior Students of Marine Engineering. New Edition. 8vo. Postage 4d. ... ... ... ... ... ... ... 6s. 0d.

**The Resistance and Power of Steamships.** By W. H. Atherton, M.Sc., and A. L. Mellanby, M.Sc. Cloth. Postage 3d. ... ... ... 5s. 0d.

**Marine Engineers: Their Qualifications and Duties.** By E. G. Constantine, A.M.I.C.E., etc. With Notes on the Care and Management of Marine Engines, Boilers, and Machinery. Crown 8vo. Cloth. Postage 4d. ... 3s. 0d.

**Practical Mechanics.** By Thos. Mackenzie, F.R.A.S. Applied to the Requirements of the Sailor. Second Edition, revised. With numerous Illustrations. Postage 3d. ... ... ... ... ... ... ... 3s. 6d.

**Practical Advice for Marine Engineers.** By Chas. W. Roberts, M.I.Mar.E. With 64 Illustrations. Crown 8vo. Cloth. Postage 3d. ... 3s. 0d.

## Model Making and Amateur Mechanics.

**Practical Boat Sailing for Amateurs.** By G. Christopher Davis. Second Edition. Revised and Enlarged, and with several new plans of Yachts. Containing particulars of the most suitable sailing boats and yachts for amateurs and Instructions for their proper handling, etc. Illustrated with numerous diagrams. Postage 4d. ... ... ... ... 3s. 0d.

**Practical Boat Building for Amateurs.** By Dixon Kemp. Second Edition, Revised and Enlarged, containing full instructions for Designing and Building Punts, Skiffs, Canoes and Sailing Boats, etc. Fully Illustrated with working diagrams Postage 3d. ... ... ... ... ... 2s. 6d.



**Model Yachts and Boats.** By J. Du V. Grosvenor. Giving their Designing, Making and Sailing. Illustrated with 118 designs and working diagrams. In Leatherette. Postage 3d. ... ... ... ... ... 2s. 6d.

**Model Stationary Engines: Their Design and Construction.** By H. Muncaster. Contains over 100 Working Drawings and Sketches. Most useful for study of small Model Engines. Postage 3d. ... 1s. 6d.

**Amateur's Companion to the Workshop.** Being a Collection of Practical Articles and Suggestions for the use of Amateur Workers, with some details as to construction of Electrical and other Models and Apparatus. Illustrated. Postage 3d. ... ... ... ... ... ... ... 1s. 6d.

**Model Steam Engine Design.** By R. M. de Vignier. Illustrated. Postage 1½d. ... ... ... ... ... ... ... 1s. 6d.

**A.B.C. of the Steam Engine.** By J. P. Lisk. With 6 Plans. Post 1½d. 1s. 6d.

**Building Model Boats.** By P. N. Hasluck. Illustrated. Postage 2d. 1s. 0d.

**Model Engineer's Handybook.** By Paul N. Hasluck. A Practical Handbook on the Construction of Model Steam Engines. With upwards of 100 Illustrations. 144 pages. 8vo. Cloth. Postage 3d. ... ... ... 1s. 0d.

**Model Sailing Yachts.** How to Build, Rig, and Sail Them. Edited by Percival Marshall, A.I.Mech.E. A practical handbook for Model Yachtsmen. Illustrated. Postage 3d... ... ... ... ... 1s. 0d.

**Model Gliders: How to Make and Fly Them.** By E. W. Twining. Beautifully coloured Birds and Butterflies to make into Gliders. Post 2d. 1s. 0d.

**Simple Mechanical Working Models: How to make and use them.** Edited by Percival Marshall, A.I.Mech.E. Gives Instructions for making Model Water Motors, Model Hot-air Engine, Cardboard Working Model Locomotives, Model Gravitation Railway, etc. Fully Illustrated. Postage 1d. 6d.

**Machinery for Model Steamers.** Edited by Percival Marshall, A.I.Mech.E. A Practical Handbook on the Design and Construction of Engines and Boilers for Model Steamers, the Use of Liquid Fuel, and the Proportions of Machinery for Model Boats. Fully Illustrated. Postage 1d. ... ... 6d.

**Model Steamer Building.** Edited by Percival Marshall, A.I.Mech.E. A Practical Handbook on the Design and Construction of Model Steamer Hulls and Fittings. Fully Illustrated. Postage 1d. ... ... 6d.

**Model Steam Turbines: How to Design and Build Them.** Fully Illustrated. Postage 1d. ... ... ... ... ... ... 6d.

**Model Steam Engines: How to Understand Them and How to Use Them.** Postage 1d. ... ... ... ... ... ... ... 6d.

## Models for Engineering Students.

**Working Models, ("X" Series),** Prepared by T. & T. G. Jones.
Model No. 1. Complete in box, with book of Notes and short Essay on the Steam Engine. Postage 3d. ... ... ... ... 2s. 6d.
Model No. 2. Complete in box, with book of Notes and short Essay on the Steam Engine. Postage 3d. ... ... ... ... 3s 0d.
Nos. 1 and 2. Complete in box, with Notes. Postage 3d ... 5s. 0d.

**Working Models.** By T. & T. G. Jones. Series 1 & 2 show at a glance the working of the various Types of Slide Valves used in modern Steam Engines. Eight Cardboard Models, in box with full explanations. Postage 2d. 2s. 6d.
Series 3. Comprising 6 Cardboard Models of modern High Speed Engines specially constructed for driving Dynamos. Complete in box, with full explanatory notes. Postage 3d.... ... ... ... 5s. 0d.

**Descriptive Geometry Models.** By Thomas Jones, Gold Medallist.
Series No. 1. Six Models with descriptive letterpress and 40 Problems for Solution. Postage 1d. ... ... ... ... 1s. 3d.
Series No. 2. Six Models with descriptive letterpress and 40 Problems for Solution. Postage 1d. ... ... ... ... 1s. 3d.
Series 1 and 2, in one volume. Postage 1½d. ... ... ... 2s 0d.

## Motor Cars and Cycles.

**Petrol Motors and Motor Cars.** By T. Hyler White, A.M.I.M.E. A Handbook for Engineers' Designers and Draughtsmen. Cloth. Illustrated. Postage 3d. ... ... ... ... ... ... 4s. 6d.

**Complete Hints and Tips for Automobilists.** From *The Autocar*. 478 suggestions for repairs, &c. Postage 4d. ... ... ... 2s. 6d.

**The Modern Motor Car. Its Management, Mechanism and Maintenance.** By W. Galloway Duncan, M.I.M.E. Illustrated Postage 3d. 2s. 6d.

**The Motor Cyclist's Handbook.** By Phœnix (C. S. Lake). The book for Motor Cyclists. Over 200 Illustrations, 264 pages and 10 pages Index. Postage 3d. ... ... ... ... ... ... 2s. 0d.

**Magnetos for Automobilists.** How made and how used. By S. R. Bottone. Postage 3d.... ... ... ... ... ... ... 2s. 0d

**Magneto and Electric Ignition.** By W. Hibbert, A.M.I.E.E. Describes the various Ignition Appliances used, with a chapter on Gearing. 90 Illustrations. Postage 2d. ... ... ... ... ... 2s. 0d.

**Ignition Devices.** For Gas and Petrol Motors. By S. R. Bottone. A chapter treats specially of Structural Details, Choice and Management of Automobiles. Illustrated. Postage 3d. ... ... ... ... ... 1s. 6d.

**The Autocar Handbook.** A Guide to the Motor Car. How to Select, Maintain and Drive an Automobile. Illustrated. Postage 3d. 1s. 6d.

**Systems of Electric Ignition for Motor Cars.** By Douglas Leechman. 111 Illustrations. Describes many different types. Postage 3d. 1s. 6d.

**The Motor Cycle Route Book for the British Isles,** with Maps. Postage 3d. ... ... ... ... ... ... ... ... 1s. 6d.

**Motor Boats Simply Explained.** By John Douglas. Well illustrated. Postage 3d. ... ... ... ... ... ... ... ... 1s. 0d.

**Cycle Building and Repairing.** Prepared under the direction of P. N. Hasluck. A Practical Manual, with 142 Illustrations. Cloth. Postage 2d. 1s. 0d.

**Petrol Motors Simply Explained.** By T. H. Hawley. Describes the principles on which Petrol Motors work, with hints on driving. Illustrated. Postage 3d. ... ... ... ... ... ... 1s. 0d.

**Practical Motor Car Repairing.** A Handbook for motor car owners and drivers. Illustrated Postage 3d. ... ... ... ... 1s. 0d

**The Art of Driving a Motor Car.** By Lord Montague. Postage 2d. 1s. 0d.

**Motor Car Mechanics for Beginners.** By W. Hayter. Postage 2d. 1s. 0d.

**The Care of the Car and How to Drive It.** By Lord Montagu and R. J. Mecredy. Postage 2d. ... ... ... ... ... 1s. 0d.

**Motor Cycles and How to Manage Them.** Fifteenth edition. Post. 3d. 1s. 0d.

**Hints and Tips for Motor Cyclists.** From "The Motor Cycle." 262 well indexed Hints and Tips. Postage 2d. ... ... ... 1s. 0d.

**How to Build a Bicycle.** By H. R. S. Williams. Illustrated. Postage 1d. 6d.

**How to Drive a Motor Cycle.** By Phoenix. 88 pages. Well illustrated. The book for all taking up Motor Cycling. Postage 1d. ... 6d.

**Tracing Troubles.** By "Road Rider." Deals with Motor Cycle Faults, their identification and their remedies simply and fully explained. Postage 2d. ... ... ... ... ... ... ... ... ... 1s. 0d.

## Pumps and Hydraulic Engineering.

**Practical Handbook on Pump Construction.** By P. R. Björling. Second Edition. 9 Plates. Crown 8vo. Postage 4d. ... ... 5s. 0d.

**Centrifugal Pumps, Turbines, and Water Motors.** By Chas. H. Innes, M.A. Including the Theory and Practice of Hydraulics (specially adapted for Engineers). Third Edition. Crown 8vo. Postage 4d. ... 4s. 6d.

**Notes on the Construction and Working of Pumps.** By Edward C. R. Marks, A.M.I.C.E., M.I.M.E. Crown 8vo. Postage 3d. ... 4s. 6d.

**Pumps and Pumping.** By M. Powis Bale, M.I.M.E. A handbook for Pump Users. Being Notes on Selection, Construction, and Management. Fourth Edition. Crown 8vo. Cloth. Postage 3d. ... ... ... 3s. 6d.



## Reference and Pocket Books.

**Engineer's Sketch Book of Mechanical Movements.** By T. W. Barber. Fourth Edition, with 2,603 Illustrations. 348 pages. 8vo. Postage 4d. 10s. 6d.

**A Pocket Book for Mechanical Engineers.** By David Allan Low, M.I.M.E. With over 1,000 specially prepared Illustrations. Fcp. 8vo. Gilt edges, rounded corners. Postage 3d.... ... ... ... 7s. 6d.

**Lockwood's Dictionary of Mechanical Engineering Terms.** By J. G. Horner, A.M.I.M.E. Comprising upwards of 6,000 definitions. Third Edition, revised, with additions. Embracing those current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smiths' and Boiler Shops, etc., etc. Crown 8vo. Cloth. Postage 4d. ... ... 7s. 6d.

**Wannan's Marine Engineer's Pocket Book.** By A. C. Wannan, C.E. Containing latest Board of Trade Rules and Data for Marine Engineers. Third Edition, revised, enlarged, and up-to-date. Square 18mo., with Thumb Index. Leather. Postage 3d. ... ... ... ... 5s. 0d.

**The Mechanical Engineer's Pocket Book.** By D. Kinnear Clark, M.Inst.C.E. Fifth Edition, thoroughly revised and enlarged, by H. H. P. Powles, A.M.I.C.E., M.I.M.E. Comprising Tables, Formulæ, Rules, and Data. A handy book of reference for daily use in Engineering Practice. 700 pages. Bound in flexible leather cover, rounded corners. Small 8vo. Postage 4d. ... ... ... ... ... ... 6s. 0d.

**The Engineers' Pocket Dictionary, French—English.** By M. Lyon. Pocket size. Words used in Mechanical and Electrical Engineering, Motor Car and Cycle Building. Postage 1d. ... ... ... 1s. 6d.

**Roofing by the Iron Square.** By Frank Nicholls. Postage, 1d. 1s. 0d

## Miscellaneous.

**Model Balloons and Flying Machines.** By J. H. Alexander, M.B.A.I.H.B. Numerous illustrations and five sheets of working drawings. Cloth. Postage 3d. ... ... ... ... ... ... 3s. 6d.

**Radium and other Radio-Active Elements.** By L. A. Levy and H. G. Willis. A popular account of Radium treated experimentally. Crown 8vo. Illustrated with drawings and 20 full-page plates. Postage 3d. 2s. 6d,

**Practical Kites and Aeroplanes.** How to make and work them. By Frederick Walker, C.E. A Practical Work on the Construction and Use of Kites and Aeroplanes. Illustrated. Postage 2d. ... ... ... 1s. 6d

**Talking Machines and Records.** A Handbook for all who use them. By S. R. Bottone. Illustrated with examples of different types of instruments with full instructions for making a simple phonograph. Postage 2d. 1s. 6d

**The Gyroscope.** By V. E. Johnson. Contains part of articles from *The Model Engineer*. Postage 1½d. ... ... ... ... 1s. 6d.

**Model Aeroplanes. How to Build and Fly Them.** By E. W. Twining. Contains five large sheets of working drawings with Book giving instructions for building three different Aeroplanes. Postage 2d. ... ... 1s. 0d.

**The Aeroplane Portfolio.** Contains nine sheets of scale drawings of Aeroplanes with book describing the machines and giving details of best flights made. Postage 2d. ... ... ... ... ... ... 1s. 0d.

**Practical Bookbinding.** By W. B. Pearce. Intended for those who wish to do their own Bookbinding. Illustrated. Postage 3d. ... 1s. 0d.

**Flying Machines, past, present and future.** By A. W. Marshall. 28 plates and other illustrations. Paper, Postage 2d. ... ... 1s. 0d.

**Beginner's Guide to the Microscope.** By Chas. E. Heath, F.R.M.S. A practical and well illustrated Guide to the use of the Microscope. Post. 3d. 1s. 0d.

**Flying: The Why and Wherefore.** Illustrated. Postage 1½d. ... 1s. 0d.

**Model Flying Machines.** Their Design and Construction. By W. G. Aston. Well illustrated and practical. Postage 3d. ... ... ... 1s. 0d.

**What a Business Man ought to Know.** Being the Daily Business Life in a Merchant's Office. Postage 2d. ... ... ... ... 1s. 0d.

**Letters that bring Business.** By the Author of What a Business Man ought to Know. Postage 2d. ... ... ... ... ... 1s. 0d.

**Systematic Memory.** Or How to Make a Bad Memory Good and a Good Memory Better. By Thos. Maclaren. Postage 2d. ... ... 1s. 0d.

**How to do More Business.** Postage 2d. ... ... ... 1s. 0d.

**Optical Instruments Simply Explained.** Describes the principles and working of some of the Optical Instruments in general use. Postage 1d. 6d.

**Simple Photographic Experiments.** Postage 1d. ... ... 6d.

**Simple Chemical Experiments.** Postage 1d. ... ... 6d.

**Patents Simply Explained.** A simple guide to the patenting of Inventions and registration of Trade Marks and Designs. Illustrated. Postage 1d. 6d.

**Windmills and Wind Motors, How to Build and Run Them.** By F. E. Powell. Well illustrated. Postage 1d.... ... ... ... 6d.

**Simple Scientific Experiments.** By Aurel De Ratti. Describes Forty-six instructive Experiments in Electricity, Magnetism, Hydraulics, Hydrostatics, Light, and Acoustics. Fully Illustrated. Postage 1d. 6d.

**Dyes, Stains, Inks, Varnishes, etc.** By Thomas Bolas. Postage 1d. 6d.

**Painting and Graining.** By S. W. Newcomb. Postage 1d. ... ... 6d.

**Meteorological Instruments and Weather Forecasts.** By H. T. Davidge. Postage 1d. ... ... ... ... ... ... ... 6d.

## Steam Engineering.

**The Steam Turbine.** By Robert M. Neilson, Wh. Ex., A.M.I.M.E. With 145 Illustrations. 8vo. Postage 6d. ... ... ... ... 18s. 0d

**A Text Book on Steam and Steam Engines.** By Prof. Jamieson, For the Use of Students Preparing for Competitive Examinations. With over 800 pages and many Illustrations, 6 folding Plates, and numerous Examination Papers. Seventeenth Edition. Revised. Postage 6d. ... 10s. 6d.

**Steam Engine Theory and Practice.** By W. Ripper. With 488 Illustrations. 8vo. Postage 4d. ... ... ... ... ... 9s. 0d.

**The Marine Steam Turbine.** A practical description of the Parson's Marine Turbine. 60 illustrations. Postage 4d. ... ... ... 12s. 6d.

**Steam Boilers.** By R. D. Munro. Showing their Defects, Management, and Construction. Fourth Edition. Fully Illustrated. Postage 3d. 4s. 6d.

**Steam Engineering.** By W. W. F. Pullen, Wh. Sc., M.I.M.E., A.M.I.C.E. A Treatise on Boilers, Steam, Gas and Oil Engines, and Supplementary Machinery, with Instructions for Carrying out numerous experiments. 558 pages. 300 Illustrations. Postage 5d. ... ... ... 4s. 0d.

**Elementary Manual of Steam and the Steam Engine.** By Prof. Jamieson. For First year Students. Ninth Edition. Revised. With Illustrations and Examination Papers. Postage 4d. ... ... 3s 6d.

**Injectors: Theory, Construction, and Working.** By W. F. Pullen, Wh. Sc., A.M.I.C.E. Second Edition. Revised and Enlarged. Crown 8vo. Postage 3d. ... ... ... ... ... ... ... 3s. 6d.

**A Handbook for Steam Users.** By M. Powis Bale, M.I.M.E., A.M.I.C.E. Giving Rules for Engine Drivers and Boiler Attendants, with Notes on Steam Engine and Boiler Management, and Steam Boiler Explosions. Fcp. 8vo, Postage 3d. ... ... ... .. ... ... ... 3s. 6d.

**Heat Engines.** By W. Ripper. Postage 3d. ... ... ... 3s. 0d.

**Modern Engines.** By Thomas W. Corbin. Describes different kinds of engines. Illustrated. Postage 3d. ... ... ... ... ... 1s. 0d.

**The Working of Steam Boilers.** By Edward G. Hiller. Postage 2d. 1s. 0d.
Ditto ditto ditto Cloth. Postage 3d. 1s. 6d.

**The Care and Management of Stationary Engines.** By C. Hurst. A Practical Handbook for Men-in-Charge. Crown 8vo. Cloth. Postage 3d. 1s. 0d.

**Model Steam Engines:** How to Understand Them and How to Run Them. By Henry Greenly. Fully Illustrated. Postage 1d. ... 6d.

**Model Boiler Making.** By E. L. Pearce. A Practical Handbook on the Designing, Making and Testing of Small Steam Boilers. Fully Illustrated with Original Working Drawings. Postage 1½d. ... ... ... 6d.

**The Slide Valve Simply Explained.** By W. J. Tennant, A.M.I.Mech.E. Gives a clear and simple explanation of the Working of the Steam Engine Slide Valve. With 86 Illustrations. Postage 1d. ... ... 6d.



## Workshop Tools and Processes.

**Pattern Making.** By Joseph Horner, A.M.I.M.E. Third Edition. Enlarged. With 486 Illustrations. A Practical Treatise embracing the Main Types of Engineering Construction, including Gearing, Sheave, and Pulleys, Screws, Machine Parts, Pumps, Estimating the Weight of Castings, etc., etc., etc. Crown 8vo. Postage 4d. ... ... ... ... ... 7s. 6d.

**Plating and Boiler Making.** By Joseph G. Horner, A.M.I.M.E. A Practical Handbook for Workshop Operations. 380 pages, with 388 Illustrations. Crown 8vo. Cloth. Postage 4d. ... ... ... ... 9s. 0d.

**Practical Sheet and Plate Metal Work.** By Evan A. Atkins. A most useful book for all working up metal. 450 Illustrations, over 500 pages. Crown 8vo. Postage 4d. ... ... ... ... ... 6s. 0d.

**Spons' Mechanics' Own Book.** A Manual for Handicraftsmen and Amateurs. Sixth Edition. 1,480 Illustrations, 720 pages. Demy 8vo. Postage 5d. 6s. 0d.

**Engineers' and General Smiths' Work.** By Thomas Moore. 248 pages, 401 illustrations. Postage 4d. ... ... ... ... ... 5s. 0d.

**Spons' Workshop Receipts.** For the Use of Manufacturers, Mechanics, and Scientific Amateurs. 4 Vols. Crown 8vo. Postage 4d. Per volume 3s. 0d.

**The Principles of Fitting.** By J. G. Horner, A.M.I.M.E. For Engineer Students. Illustrated with 350 Illustrations, and containing an Appendix of Useful Shop Notes and Memoranda. Fourth Edition. Postage 4d. 5s. 0d.

**Workshop Appliances.** By C. P. B. Shelley, M.I.C.E. Giving Descriptions of some of the Gauging and Measuring Instruments, Hand cutting Tools, Lathes, Drilling, Planing, etc. With an additional chapter on Milling, by R. R. Lister. With 328 Illustrations. Fcp. 8vo. Postage 4d. 5s. 0d.

**Watch Repairing, Cleaning and Adjusting.** By F. J. Garrard. A Practical Handbook dealing with the materials and Tools used, and the Methods of Repairing, Cleaning, Altering and Adjusting of English and Foreign Watches, etc. With over 200 Illustrations. Crown 8vo, Cloth. Postage 4d. ... 4s. 6d.

**Practical Ironfounding.** By J. G. Horner, A.M.I.M.E. Illustrated with over 100 Engravings. Third Edition. Postage 3d. ... ... 3s. 6d.

**Workshop Makeshifts.** By H. J. S. Cassall. Being a Collection of Practical Hints and Suggestions for the use of Amateur Workers in Wood and Metal. Fully Illustrated. Cloth gilt. Postage 3d. ... ... ... 2s. 6d.

**Practical Lessons in Metal Turning.** By Percival Marshall, A.I.Mech.E. A Handbook for Young Engineers and Amateur Mechanics. With 200 Original Illustrations. Fourth Edition. 182 pages. Postage 3d. 2s. 0d.

**The New Turner's and Fitter's Handbook.** By T. Greenwood. A complete Guide to Screw-cutting with many Tables. Postage 2d.... 2s. 0d.

**Practical Plumbers' Work.** By Paul N. Hasluck. 289 illustrations. Postage 3d. ... ... ... ... ... ... 2s. 0d.

**Simple Decorative Lathe Work.** By James Lukin, B.A. A Practical Handbook of the Construction and Use of the ordinary Turning Lathe for the purpose of the Art. Fully Illustrated. Postage 2d. ... ... 2s. 0d.

**Screw Threads, and Methods of Producing Them.** By Paul N. Hasluck. With numerous Tables and complete Directions for using Screw Cutting Lathes. Fifth Edition. Waistcoat pocket size. Postage 1d. ... 1s. 6d.

**Workshop Mathematics. Parts I. and II.** By F. Castle, M.I.M.E. 8vo. Postage 2d. ... ... ... ... ... each 1s. 6d.

**Turning for Beginners.** By J. Lukin. Being Elementary Instruction in the Art of Turning in Wood and Metal. Postage 3d. ... ... 1s. 6d.

**The Possibilities of Small Lathes.** By James Lukin, B.A. Including particulars and details for making an inexpensive overhead, and other useful accessories for, and notes on, the choice of a Lathe. Fully Illustrated. Cloth. Postage 3d. ... ... ... ... ... 1s. 6d.

**Workshop Wrinkles and Recipes.** Edited by Percival Marshall. A Collection of Useful Hints in Mechanics and Electricity. Postage 3d. 1s. 0d

**Pattern Maker's Handybook.** By Paul N. Hasluck. A Practical Manual on the Construction of Patterns for Founders. With upwards of 100 Illustrations. 144 pages. Crown 8vo. Cloth. Postage 3d. ... ... 1s. 0d.

**Engraving Metals.** Prepared under the direction of Paul N. Hasluck. Practical Manual. 177 Engravings and Diagrams. Cloth. Post 2d. 1s. 0d.

**The Induction Coil in Practical Work, including Rontgen X-Rays.** By Lewis Wright. With Illustrations. Crown 8vo. Postage 3d. 4s. 6d.
**Secondary Batteries.** A practical Handbook for Owners and Attendants, By an Engineer. Postage 4d. ... ... ... ... ... 4s. 0d.
**Electric Instrument-Making for Amateurs.** By S. R. Bottone. A Practical Handbook. With 96 Illustrations. Seventh Edition. Revised and Enlarged. Postage 3d. ... ... ... ... ... ... 3s. 6d.
**Induction Coils.** By G. E. Bonney. Fourth Edition. 104 Illustrations. Postage 4d. ... ... ... ... ... ... ... ... 3s. 0d.
**Electro Chemistry.** By G. Gore. Postage 3d. ... ... ... 2s. 0d.
**Dry Batteries.** How to Make and Use Them. By a Dry Battery Expert. Illustrated. Postage 2d. ... ... ... ... ... 1s. 6d.
**Experimenting with Induction Coils.** By H. S. Norrie. Contains practical directions for using Induction Coils and Tesla Coils. Postage 2d. 1s. 6d.
**Practical Induction Coil Construction.** By John Pike. A handbook of constructive details and workshop methods used in building and repairing modern spark coils. Illustrated. Postage 3d. ... ... 1s. 0d.
**Induction Coils for Amateurs: How to Make and Use Them.** Edited by Percival Marshall, A.I.Mech.E. Fully Illustrated. Postage 1d. 6d.
**Simple Electrical Working Models: How to Make and Use Them.** Edited by Percival Marshall, A.I.Mech.E. 48 Illustrations. Postage 1d. 6d.
**Small Accumulators: How Made and Used.** Edited by Percival Marshall, A.I.M.E. With 41 Illustrations. Seventh Edition. Postage 1d. 6d.
**Electric Batteries: How to Make and Use Them.** Edited by Percival Marshall, A.I.Mech.E. Fully Illustrated. Sixth Edition. Postage 1d. 6d.
**Small Electrical Measuring Instruments.** Describes the Making and Using Galvanometers, Voltmeters, &c. Fully Illustrated. Postage 1d. 6d.
**The Wimshurst Machines and other Static Electrical Apparatus Simply Explained.** By A. W. Marshall. Postage 1d. ... 6d.
**Magnets and Magnetism Simply Explained.** By A. W. Marshall. Postage 1d. ... ... ... ... ... ... ... 6d.

## Elementary Text Books on Electricity and Magnetism.

**The Elements of Electrical Engineering.** By Tyson Sewell, A.I.E.E. A First Year's Course for Students. Fourth Edition. Postage 4d. 5s. 0d.
**Elementary Lessons in Electricity and Magnetism.** By Sylvanus P. Thompson, D.Sc., F.R.S. Illustrated. Fcp. 8vo. Postage 3d. 4s. 6d.
**Elementary Manual of Magnetism and Electricity.** By Prof. Jamieson. For First Year Students. Fifth Edition. With Illustrations and Examination Papers. Crown 8vo. Postage 3d. ... ... ... ... 3s. 6d.
**First Book of Electricity and Magnetism.** By Perren Maycock, M.I.E.E. Fourth Edition, revised and enlarged. With 162 Illustrations. Postage 3d. ... ... ... ... ... ... ... ... 2s. 6d.
**Magnetism and Electricity for Beginners.** By H. E. Hadley, B.Sc. (Lond.) Adapted to the Elementary Stage of the S. Kensington Syllabus. Globe 8vo. Postage 3d. ... ... ... ... ... ... ... ... 2s. 6d.
**Practical Exercises in Magnetism and Electricity.** By H. E. Hadley. A well-illustrated book giving a large number of exercises. Post. 3d. 2s. 6d.
**Problems and Solutions in Elementary Electricity and Magnetism.** By W. Slingo and A. Brooker. With 98 Illustrations. Crown 8vo. Postage 3d. ... ... ... ... ... ... ... 2s. 0d.
**Electrical Engineering.** By S. R. Bottone. Gives constructional Details of Appliances described. Illustrated. Postage 3d. ... ... 1s. 6d.
**The Study of Electricity for Beginners.** By Norman H. Schneider. Comprising Elements of Electricity and Magnetism. Postage 2d. 1s. 6d.
**Electrical Circuits and Diagrams.** By Norman H. Schneider. Gives 217 Diagrams of Connections. Postage 2d. ... ... ... 1s. 6d.
**Electrical Circuits and Diagrams. Part II.** Alternating Current Generators and Motors, Single phase and Polyphase Transformers, etc., etc. 69 Diagrams. Postage 2d. ... ... ... ... ... 1s. 6d.



## Miscellaneous Electrical Subjects.

**Medical Electricity.** A practical Handbook for Students and Practitioners. 12 plates and Illustrations. Postage 6d. ... ... ... 12s. 6d.
**Electric Traction.** By J. H. Rider, M.I.E.E., M.I.C.E. With numerous Illustrations. A Practical Handbook on the Application of Electricity as a Locomotive Power. Crown 8vo. Cloth. Postage 6d. ... 10s. 6d.
**The Alternating-Current Circuit and Motor.** By W. Perren Maycock, M.I.E.E. An Introductory and Non-Mathematical Book for Engineers and Students. SecondEdition. Revised. With 140 Illustrations. Postage 3d. 4s. 6d.
**The Electro-Platers' Handbook.** By G. E. Bonney. A Practical Manual for Amateurs and Students in Electro Metallurgy. Fourth Edition. Revised and Enlarged, with an Appendix on Nickel Plating for Cycles. Postage 3d. ... ... ... ... ... ... ... net 2s. 6d.
**Practical Electro-Plating.** By Geo. Gentry. Deals fully with the Electro-Deposition of Metals. Illustrated. Postage 3d. ... ... 1s. 0d.
**Simple Experiments in Static Electricity.** A Series of Instructive and Entertaining Experiments for Students and Amateurs. Fully Illustrated. Postage 1d. ... ... ... ... ... ... 6d.
**X Rays Simply Explained.** A Handbook on the Theory and Practice of Radiography. Fully Illustrated. Postage 1d. ... ... ... 6d.
**Alternating Currents Simply Explained.** By A. W. Marshall. Postage 1d. 6d.
**Practical Dynamo and Motor Management.** Illustrated. Postage 1d. 6d.

## Reference and Pocket Books.

**A Pocket Book of Electrical Rules and Tables.** By J. Munro, C.E., and Prof. Jamieson. With numerous Diagrams. Sixteenth Edition, thoroughly revised and enlarged. For the use of Electricians and Engineers. Leather. Pocket size. Postage 3d. ... ... ... ... ... 8s. 6d.
**Molesworth's Pocket Book of Engineering Formulæ.** A useful book for Civil, Mechanical and Electrical Engineers. Contains many Tables of interest. Pocket size, 899 pages. Postage 2d. ... ... 5s. 0d.
**A Guide to the Electrical Examinations.** By F. H. Taylor. A Handbook of Reference for Students and Teachers, with an appendix of specimen Questions and Answers. Cloth. Postage 3d. ... ... 1s. 6d.
Ditto ditto Paper. Postage 2d. ... ... ... ... 1s. 0d.
**Whittaker's Electrical Engineer's Pocket Book.** Edited by Kenelm Edgcumbe, A.M.I.E.E. With 143 Illustrations. Leather, Postage 4d. 5s. 0d.
**The Handy Electrical Dictionary.** By W. L. Weber, M.E. Gives several thousand definitions. 224 pages. Pocket size. Postage 1d. Cloth. 1s. 0d.
Leather. Postage 1d. ... ... ... ... ... 1s. 9d.

## Telephones, Telegraphy, and Bells.

**Telegraphy.** By Sir W. H. Preece, K.C.B., F.R.S., V.P.In., and Sir J. Sivewright, K.C.M.G. With 267 Illustrations. Fcp. 8vo. Postage 5d. 7s. 6d.
**Telegraphy.** A Detailed Exposition of the Telegraph System of the British Post Office. By T. E. Herbert, A.M.I.E.E. 50 Illustration. 900 pages. Postage 5d. ... ... ... ... ... ... 6s. 6d.
**The Practical Telephone Handbook.** By Joseph Poole, A.I.E.E., Wh.Sc. With 530 Illustrations. New Edition, revised and enlarged. Postage 5d. ... ... ... ... ... ... ... ... 6s. 0d.
**Practical Electric Bell Fitting.** By F. C. Allsop. Tenth Edition. 186 Illustrations. Crown 8vo. Postage 3d. ... ... ... ... 3s. 6d.
**Telephones: Their Construction and Fitting.** By F. C. Allsop. Eighth Edition. 184 Illustrations. Crown 8vo. Postage 4d. ... ... 3s 6d.
**Practical Telephony.** By Jas. Bell, A.I.E.E., and S. Wilson. A Simple and Practical Handbook for the use of Students and Employees. Copiously Illustrated. Postage 4d. Fifth Edition. Revised ... ... 3s. 6d.
**Electric Bells, and All About Them.** By S. R. Bottone. A Practical Book for Practical Men. With more than 100 Illustrations. Seventh Edition, revised and enlarged. Postage 3d. ... ... ... ... ... 2s. 0d.

**Wireless Telegraphy and Hertzian Waves.** By S. R. Bottone. Fourth Edition, revised. With 37 Illustrations. Postage 3d. ... ... 2s. 6d.
**Elementary Telegraphy.** By H. W. Pendry. A Manual for Students. Well Illustrated. Postage 3d. ... ... ... ... 2s. 6d.
**Telegraphists' Guide.** By Jas. Bell, A.I.E.E., and S. Wilson, A.M.I.E.E. Seventh Edition. 208 Cuts. Postage 3d. ... ... ... 2s. 0d.
**Wireless Telegraphy for Amateurs.** By R. P. Howgrave Graham. New and thoroughly revised edition. Postage 3d. ... ... 2s. 0d.
**How to Instal Electric Bells, Annunciators and Alarms.** By Norman H. Schneider. Gives some 59 Diagrams. Postage 2d. ... ... 1s. 6d.
**Wireless Telephones.** By J. Erskine Murray. Gives a description of Apparatus used. Illustrated. Postage 3d .... ... ... 1s. 6d.
**Wireless Telephone Construction.** By Newton Harrison. Well-illustrated description of Apparatus, and instructions how to make. Post. 2d. 1s. 6d.
**Making Wireless Outfits** By Newton Harrison. Illustrated. Post. 2d. 1s. 6d.
**Wires and Wireless.** By T. W. Corbin. Including Wireless and Submarine. Illustrated. Postage 3d. ... ... ... ... ... 1s. 0d.
**Telephone Troubles and How to Find Them.** By W. H. Hyde. A complete Handbook for the Telephone Inspector. Postage 1d. ... 6d.
**Electric Bells and Alarms.** By F. B. Powell. Gives instructions for fitting same to any part of any ordinary building. 51 Illustrations. Seventh edition. Postage 1d.... ... ... ... ... ... 6d.
**Telephones and Microphones: How to Make and Use Them.** Edited by Percival Marshall, A.I.Mech.E. A Practical Handbook on the Making and Using of Simple Forms of Telephones and Microphones. Fifth Edition. With 29 Illustrations. Postage 1d.... ... ... ... ... 6d
**Wireless Telegraphy Simply Explained.** By H. T. Davidge. Postage 1d. ... ... ... ... ... ... ... 6d.

# WOODWORKING, ETC.

**Modern Practical Joinery.** By G. Ellis. With 1,000 Illustrations. Imperial 8vo. Postage 5d. ... ... ... ... ... ... 15s. 0d.
**Practical Stair Building and Handrailing.** By W. H. Wood. With 32 Plates. Crown 4to. Postage 5d. ... ... ... ... 10s. 6d.
**The Art and Craft of Cabinet Making.** By D. Denning. A Practical Handbook to the Construction of Cabinet Furniture, the Use of Tools, Formation of Joints, Hints on Designing and Setting Out Work, Veneering, etc. With 219 Illustrations. Postage 4d. ... ... ... ... 5s. 0d.
**Cabinet Making for Amateurs.** Being Clear Directions How to Construct many Useful Articles, such as Brackets, Sideboards, Tables, Cupboards, etc. Illustrated. Cloth gilt. Postage 3d. ... ... ... ... 2s. 6d.
**The Cabinet-Maker's Guide to the Entire Construction of Cabinet Work.** By Richard Bitmead. Illustrated with Plans, Sections and Working Drawings, including Veneering, Marquetrie, Buhlwork, Mosaic, Inlaying, etc. Crown 8vo. Cloth. Postage 3d. ... ... ... 2s. 6d.
**Carpentry and Joinery Workshop Practice.** By C. F. and A. G. Mitchell. A Manual for the use of Students. Cloth gilt. Postage 3d. 1s. 6d
**Circular Work in Carpentry and Joinery.** By George Collings. A Practical Treatise on Circular Work of Single and Double Curvature. With Diagrams. Third Edition. 12mo. Cloth. Postage 3d. ... ... ... 2s. 6d.
**Practical Graining and Marbling.** By Paul N. Hasluck. With numerous Illustrations. 160 pages. Crown 8vo. Cloth. Postage 3d. ... 2s. 0d.
**Practical Staircase Joinery.** By Paul N. Hasluck. With numerous Illustrations in the text. 160 pages. Crown 8vo. Cloth. Postage 3d 2s. 0d.
**French Polishing and Enamelling.** By R. Bitmead. A Practical Work for Instruction. Including Numerous Recipes for Making Polishes, Varnishes, Glaze-Lacquers, etc. Postage 2d. ... ... ... ... 1s. 6d.
**Wood-Carving for Amateurs.** By D. Denning. Full Instructions for Producing all the Different Varieties of Carvings. Second Edition. In Paper. Postage 2d. ... ... ... ... ... ... ... 1s. 0d.
**Chip Carving and other Surface Carving.** By Eleanor Rowe. With 71 Illustrations. The book has been written for the homeworker. Post. 2d. 1s. 0d.



**Marquetrie Woodstaining for Amateurs.** By Eliza Turck. A Practical Handbook to Marquetrie Woodstaining and Kindred Arts. Profusely Illustrated. In Paper. Postage 2d. ... ... ... ... 1s. 0d.
**Mounting and Framing Pictures.** Prepared under the direction of Paul N. Hasluck. A Practical Manual with 240 Illustrations. Cloth. Postage 2d. 1s. 0d.
**Woodworker's Handybook.** By Paul N. Hasluck. Embracing Information on the Tools, Material Appliances and Processes Employed in Woodworking. With 104 Illustrations. 144 pages. 8vo. Cloth. Postage 3d. ... 1s. 0d.
**Wood-Turner's Handybook.** By Paul N. Hasluck. A Practical Manual for Workers at the Lathe, with over 100 Illustrations. 144 pages. Crown 8vo. Cloth. Postage 3d. ... ... ... ... ... 1s. 0d.
**The Beginner's Guide to Carpentry.** By H. Jarvis. A Practical Handbook for all Beginners in Carpentry. Illustrated with Drawings and Photos showing how Tools should be used. Crown 8vo. Postage 3d. 1s. 0d.
**Polishes and Stains for Woods.** By David Denning. A Complete Guide to Polishing Woodwork, with directions for Staining, and full Information for making the Stains, Polishes, etc. In Paper. Postage 2d. ... 1s. 0d.
**House Decoration: Comprising Whitewashing, Paperhanging, Painting, etc.** By Paul N. Hasluck. A Practical Manual with 79 Illustrations. Cloth. Postage 2d. ... ... ... ... ... 1s. 0d.
**Domestic Jobbing.** Gives details of useful repairs. Soldering, Chair Caning, Umbrella Repairing, Lock Repairing, and Key Fitting, &c. Illustrated. Postage 2d. ... ... ... ... ... ... 1s. 0d.
**Cabinet Worker's Handybook.** By Paul N. Hasluck. A Practical Manual on the Tools, Materials, Appliances, and Processes Employed Cabinet Work. With upwards of 100 Illustrations. 144 pages. 8vo. Cloth. Postage 3d. ... ... ... ... ... 1s. 0d.
**Staining and Polishing.** With Chapters on Stencilling and Ornamental Lettering. Many Recipes. Postage 3d. ... ... ... 1s. 0d.
**Soft Woods and Colonial Timbers.** A practical handbook on the selection and uses of Soft Woods and Colonial Timbers. Fully illustrated. Postage 1d. ... ... ... ... ... ... ... ... 6d.
**Hardwoods, English and Foreign.** Describes Hard and Fancy Woods used by carpenters and cabinet makers. Illustrated. Postage 1d. ... 6d.
**Woodwork Joints: How to Make and Where to Use Them.** By a Practical Joiner. Postage 1d. ... ... ... ... 6d.
**Veneering, Marquetry and Inlay.** A Practical Guide to these interesting methods of decorating woodwork. Fully illustrated. Postage 1d. 6d.
**Fretwork.** Containing full instructions on Tools, Materials, and Methods of Working. Illustrated. Postage 1½d. ... ... ... 6d.
**How to Use the Stanley Universal Plane for Moulding, Matching, Ploughing, etc.** By a Practical Woodworker. Illustrated. Post. 1d. 6d.
**Elementary Wood Carving.** Being a Practical Guide to Relief and Incised Carving. Fully Illustrated. Postage 1½d. ... ... ... ... 6d.
**Doormaking for Carpenters and Joiners.** Fully Illustrated. Postage 1½d. ... ... ... ... ... ... ... 6d.
**Practical Polishing, Staining, etc. for Woodwork.** Gives methods of Staining, etc. Postage 1d. ... ... ... ... ... 6d.
**Window Making for Carpenters and Joiners.** 121 Illustrations. A most useful book. Postage 1d. ... ... ... ... ... 6d.
**Simple Lessons in Wood Turning.** 97 Illustrations, Diagrams and Working Drawings. Postage 1d. ... ... ... ... 6d.
**Practical Upholstery.** Fully Illustrated. Postage 1d.... ... ... 6d.
**Violin Making and Adjusting.** The Construction and Adjustment of Violins and 'Cellos fully described. Illustrated. Postage 1d. ... ... 6d.
**Jewellery Enamelling.** Dealing with various processes in vogue. Well illustrated. Postage 1d. ... ... ... ... ... 6d.
**Elementary Staircasing.** The principles and methods of construction clearly described. 119 illustrations. Postage 1d. ... ... ... 6d.
**Design for Wood Carvers.** Giving particulars of principles of Designs. Postage 1d. ... ... ... ... ... ... ... 6d.
**Marquetry Made Easy.** A well Illustrated book. Useful to all interested in Marquetry. Postage 1½d.... ... ... ... ... 6d.

## PERIODICALS.

**"The Model Engineer."** Contains Practical Articles, Original Working Drawings and High-class Illustrations on Model Engine Making, Lathe Work, Pattern Making, Sheet Metal Working, Brass and Iron Founding, Small Dynamos, etc. Every Thursday, 2d. net. Annual Subscription, post free ... ... ... ... ... **13s. 0d.**

Vols. I, II, III, are entirely out of print.
Vol. IV, Jan. to June, 1901; Vol. V, July to Dec., 1901; Vol. VI, Jan. to June, 1902; Vol. VII, July to Dec., 1902. Postage 4d. Foreign and Colonial 6d. each ... ... ... ... ... **3s. 6d**
Each Vol. contains 12 parts.

Vol. VIII, Jan. to June, 1903; Vol. IX, July to Dec., 1903; Vol X. Jan. to June, 1904; Vol. XI, July to Dec., 1904; Vol. XII, Jan. to June, 1905: Vol. XIII, July to Dec., 1905; Vol. XIV, Jan. to June, 1906; Vol. XV, July to Dec., 1906; Vol. XVI, Jan. to June, 1907; Vol. XVII, July to Dec., 1907; Vol. XVIII, Jan. to June, 1908; Vol. XIX, July and Dec., 1908; Vol. XX, Jan. to June, 1909; Vol. XXI, July to Dec., 1909; Vol. XVII, Jan. to June, 1910; Vol. XVIII, July to Dec., 1910; Vol. XVIV, Jan. to June, 1911; Vol. XXV, July to Dec., 1911; Vol. XXVI, Jan, to June, 1912; Vol. XXVII, July to Dec., 1912; Vol. XXVIII., Jan. to June, 1913. Postage 6d. Foreign and Colonial 1s. each **6s. 6d.**
Each Vol. contains 26 parts.

Binding Cases for Vol. Postage 3d. ... ... ... **1s. 0d.**

Reading Cases, with Strings, for the Temporary Binding of Twelve Parts. Postage 3d. ... ... ... ... ... ... **1s. 0d.**

**"The Engineer-in-Charge and Works Manager."** A Practical Journal of Engineering, Plant Management, and Maintenance.

Vol. I, April, 1906 to March, 1907; Vol. II, April, 1907 to March, 1908; Vol. III, April, 1908 to March, 1909; Vol. IV, April, 1909 to March, 1910; Vol. V, April, 1910 to March, 1911; Vol. VI, April, 1911 to March, 1912. Postage 5d. Foreign and Colonial 1s.... ... ... **4s. 6d.**

Binding Case for Vol. Postage 3d. ... ... ... **1s. 6d.**

Reading Cases, with Strings, to hold Twelve Parts, Postage 3d. **1s. 6d.**

**The Power User, Engineer-in-Charge, and Works Manager.** A Practical Journal of Engineering Plant Installation Management and Maintenance. Published on the 1st of the month. Price 4d., post free, 6d. Annual Subscription ... ... ... ... **6s. 0d.**

Vol. VII., April, 1912 to March, 1913. Postage 6d. Abroad 1/6 net **6s. 0d**

**"Junior Mechanics and Electricity."** A new Journal for beginners of all ages, deals with Tools and Tool Making, Lathes, &c., Aeroplanes, Model Boats, Electric Motors, Dynamos, etc. Will interest all mechanically inclined. Monthly, 2d. net. Annual Subscription, post free **3s. 0d.**


# A USEFUL SET.

**Gas Engines: Their Advantages, Action and Application.** By W. A. TOOKEY. Hints to Purchasers, Erectors and Attendants.

**Oil Engines: Stationary and Marine.** By W. A. TOOKEY. Many Types of Engines Illustrated. A Practical Book.

**Gas Producers for Power Purposes.** By W. A. TOOKEY. For the use of Purchasers, Erectors and Attendants.

**How to Manage a Suction Gas Producer.** By W. A. TOOKEY. Illustrated.

*Price* **1s.** *each, net, from all Booksellers, or* **1s. 2d.** *each post free from*

**PERCIVAL MARSHALL & CO., 26-29, Poppin's Court, Fleet Street, London, E.C.**

## PRACTICAL LESSONS IN
# METAL TURNING:

**A Handbook for Young Engineers & Amateur Mechanics.**

BY

**PERCIVAL MARSHALL, A.I.Mech.E.**

An excellent book for anyone who wishes to learn how to use a Lathe. The various Tools and their uses are described, many of them being illustrated.

There is a chapter on Screw Cutting, and over 200 Illustrations of tools and appliances.

Price **2/-** net, or Post Free **2/3**.

*Of all Booksellers, or*

PERCIVAL MARSHALL & CO.,

26-29, POPPIN'S COURT, FLEET ST., LONDON, E.C.

## THE MOTOR CYCLIST'S HANDBOOK.

**By "PHŒNIX" (C. S. LAKE).**

Chapters—I. The Engine; its working principle. The four-stroke cycle; Valves and means of operating them. II. The engine (continued). The two-stroke or valveless system. III. Twin and four-cylinder cycle engines (four-stroke systems). IV. Constructional details of motor cycle engines. V. Compression. VI. The Carburettor. VII. The ignition. VIII. The transmission; Belt and chain drives; Free engine clutches, and variable speed gears. IX. Lubrication. X. The springing of motor cycles, XI. Overhauling and tuning-up the engine, etc. XII. The machine as a whole. The selection and purchase of new and second-hand machines. Driving hints. Passenger motor cycles. The cost of motor cycling. XIII. Accessories and equipment. XIV. The Law in relation to motor cycling. Price **2s.** net; post free **2s. 3d.**

## ENGINEERING MATHEMATICS SIMPLY EXPLAINED. By H. H. HARRISON.

Chapters—I. Arithmetic. II. Vulgar and Decimal Fractions. III. Powers of Numbers—Square Roots. IV. Algebra. V. Trigonometry. VI. Mensuration. VII. Logarithms. VIII. Use of Squared Paper—Finding the Law of a Curve—Plotting Curves. IX. The Elements of the Differential Calculus. Price **1s. 6d.** net; post free, **1s. 9d.**

## MOTOR BOATS SIMPLY EXPLAINED.

**By JOHN DOUGLAS.**

Chapters—I. Boat Construction. II. Description of Motor. III. Fuel for Motors. IV. Ignition. V. Propellers and Driving Gear. VI. Hints on the Maintenance and Running of a Motor Boat. Appendix. Well illustrated. Price **1s.** net; post free, **1s. 3d.**

## HANDY ELECTRICAL DICTIONARY.

**Compiled and Edited by W. L. WEBER, M.E.**

This is the book which will assist you when an electrical word or expression of which you do not know the meaning crops up in business or when reading. It is a practical Handbook of Reference, containing Definitions of every used Electrical Term or Phrase. Indispensable to everyone interested in electrical science. It is pocket size, but contains no less than 224 pages, giving several thousand definitions of electrical words and phrases, arranged in alphabetical order, so that you can find what you want at once. Cloth, price **1s.** net; post free, **1s. 1d.** Leather, price **1s. 9d.** net; post free, **1s. 10d.**

---

PERCIVAL MARSHALL & Co., 26-29, Poppin's Court,
FLEET STREET, LONDON, E.C.

## The A.B.C. of Dynamo Design.

By ALFRED H. AVERY, A.I.E.E.

An Illustrated Handbook describing General Principles of Dynamo Design. Folding Plate of 500-watt Dynamo. Chapters—I. General Principles of Dynamo Design. II. The Armature. III. Armature Action and Reaction. IV. The Construction and Winding of Armatures. V. The Field Magnet. VI. Design for a 30-watt Dynamo. VII. Design for a 500-watt Dynamo. VIII. Design for a 2-kilowatt Dynamo. IX. Notes on Dynamo Construction and Winding. Price 2s. net; post free, 2s. 3d.

## Private House Electric Lighting.

By FREDERIC H. TAYLOR, A.M.I.E.E.

Describes modern methods of Wiring and Fitting, and is fully illustrated. Chapters—I. Systems of Supply. II. Systems of Wiring. III. Conductors, Jointing, &c. IV. Arrangement of Circuits, &c. V. Arrangement of Lamps. VI. Switching Arrangements and Switches. VII. The Testing of an Installation. VIII. Accessories, Fittings, and Lamps. IX. Cost of Installation Work. X. Cost of Using Electric Light. XI. Generating Plant. Price 1s. net; post free 1s. 3d.

## A Guide to the Electrical Examinations.

A Handbook of Reference for Students and Teachers, with an appendix of Specimen Questions and Answers. By FREDERIC H. TAYLOR, A.M.I.E.E., Mem. Society of Arts. Contents—Section I. City and Guilds Department of Technology—Particulars of Examinations in Electric Lighting and Power Transmission—Telegraphy and Telephony and Electro-Metallurgy. II. The Board of Education Examinations in Magnetism and Electricity. III. Particulars of Examination Fees and Certificates and Awards. IV. Notes on the Preparation for Examination. V. Hints on Working Examination Papers. VI. Specimen Questions and Answers. Price, paper cover, 1s. net; post free, 1s. 2d.; cloth, 1s. 6d. net; post free, 1s. 9d.

---

*To be obtained from all Booksellers, or post free from*

**PERCIVAL MARSHALL & CO.,**

**26-29, Poppin's Court, Fleet St., London, E.C.**

THE

# MODEL ENGINEER and ELECTRICIAN.

EDITED BY

PERCIVAL MARSHALL, A.I.Mech.E.

**Published every Thursday. Price 2d. Post Free, 3d.**

A Splendid Paper for Young Engineers, Apprentices, Students, and Amateurs interested in Mechanics and Electricity.

## Special Features:

**Practical Articles** by experienced writers on the construction and working of model steam, gas, and oil engines; model locomotives and railways; model boilers; model steam and electric launches, and sailing yachts; model aeroplanes; motor cycles; lathes and metal and woodworking tools; pattern making; brass and iron founding; forging; model dynamos and motors; electric bells, telephones, and batteries; accumulators; electric lighting; influence machines; electrical experiments, etc., etc.

**Model Engineers and their Work.**—Illustrated Interviews with prominent model engineers, describing their workshops, their methods of working, and some of the models they have made. These are most interesting and instructive articles, and are fully illustrated from photographs.

**Our Beginners' Column.**—A section devoted to elementary instruction on the use of tools, the making of simple apparatus and models, and the carrying out of easy electrical and other scientific experiments.

**Practical Letters from our Readers.**—A correspondence column, wherein readers can describe workshop appliances or methods of their own invention, and discuss practical matters of mutual interest.

**News of the Trade.**—Under this heading short descriptions of new tools, apparatus, and materials are inserted, thus keeping the reader posted up in the latest improvements connected with his hobby.

**A System of Queries and Replies,** by which all readers of the Journal requiring information and advice on mechanical or electrical subjects can obtain replies by post within a few days. All replies of general interest are published in the following issue of the paper, so that while the individual enquirer can obtain the required assistance promptly, the remainder of the readers are not deprived of the interesting miscellany which a "Queries and Replies Column" always affords.

**Original Working Drawings** and high-class illustrations are a regular feature of the Journal.

**Prize Competitions,** open to all readers, are announced from time to time, the subjects of which are sufficiently diverse in character to suit the tastes of both mechanical and electrical workers.

**Send 3d. for Specimen Copy.**

PERCIVAL MARSHALL & CO.

26-29, Poppin's Court, Fleet Street, LONDON, E.C.

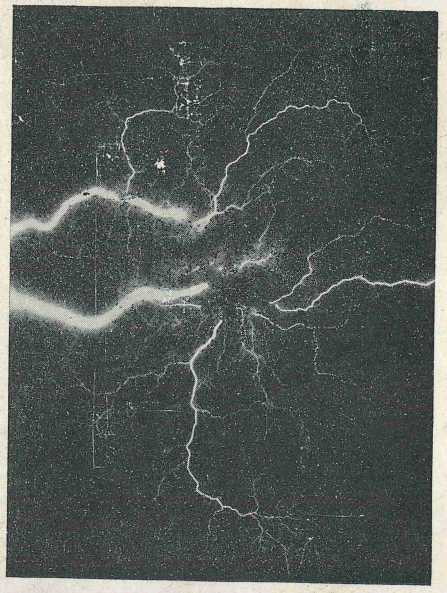
PRACTICAL INDUCTION COIL CONSTRUCTION. 1/- net. 8

No. 8.

MARSHALL'S PRACTICAL MANUALS.

# PRACTICAL INDUCTION COIL CONSTRUCTION

PRICE 1/- NET...



FULLY ..... ILLUSTRATED

PERCIVAL MARSHALL & CO., LONDON, E.C.